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CONTENTS

PAGE.

Index to Papers and Discussions, ... vi

List of Officers, ... vii

List of Members, Associates, and Juniors, ... viii

Articles of Incorporation, ... xvi

Constitution and By-Laws, ... xviii

PROCEEDINGS OF THE TWENTY-SECOND GENERAL MEETING OF THE SOCIETY, HELD IN NEW YORK, DECEMBER 10 AND 11, 1914.

Introductory Proceedings, ... xxv

Report of Secretary and Treasurer, ... xxvi

Election of New Members, ... xxxii, 105

Election of Officers, ... xxxii

President's Address, ... xxxiv

Report of the Committee on Revision of Constitution and By-Laws, . . xxxix

Report of the Committee on Endowment, ... xli

Alfred Noble Memorial, ... xlii

Second Session, Thursday, December 10, ... 56

Third Session, Friday, December 11, ... 105

Resolution Relating to Development of Foreign Commerce, . . . 105

Fourth Session, Friday, December 11, ... 156

Letter from President Thompson, ... 207

Appendix—International Convention Relating to Safety of Life at Sea, . . 209

Obituary, ... 313

INDEX TO PAPERS AND DISCUSSIONS

THURSDAY, DECEMBER 10, 1914.

INTERNATIONAL CONFERENCE ON SAFETY OF LIFE AT SEA: 1
By E. T. Chamberlain, Esq., Honorary Associate.

SAFETY OF LIFE AT SEA. APPLICATION OF SUBDIVISION RULES ADOPTED AT INTERNATIONAL CONFERENCE: 9
By James Donald, Esq., Member.

SAFETY OF LIFE FROM FIRE AT SEA: 31
By W. O. Teague, Esq., Visitor.

THE EXPANSION OR CONTRACTION OF DIMENSIONS AND THE EFFECT UPON RESISTANCE: . 57
By Professor Herbert C. Sadler, Member of Council.

SOME EXPERIMENTS WITH MODELS HAVING RADICAL VARIATIONS OF AFTER SECTIONS: 61
By Naval Constructor D. W. Taylor, U. S. N., Vice-President.

STABILITY OF VESSELS AS AFFECTED BY DAMAGE DUE TO COLLISION: 67
By William Gatewood, Esq., Member.

THE THERMODYNAMICS OF THE MARINE OIL ENGINE: 75
By John F. Wentworth, Esq., Visitor.

LAUNCHING DATA FOR A BATTLESHIP: 91
By Naval Constructor John G. Tawresey, U. S. N., Member.

FRIDAY, DECEMBER 11, 1914.

RECENT DEVELOPMENTS IN SUBMARINE SIGNALING: 107
By J. B. Millet, Esq., Visitor.

SUBMARINE SIGNALING AND A PROPOSED METHOD OF SAFE NAVIGATION IN FOG: . . 115
By Commander F. L. Sawyer, U. S. N., Member.

THE BEHAVIOR OF RIVETED JOINTS UNDER STRESSES: 133
By James E. Howard, Esq., Visitor.

OUR FIRST FRIGATES. SOME UNPUBLISHED FACTS ABOUT THEIR CONSTRUCTION: . . 139
By Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy.

REFUELING WARSHIPS AT SEA: 157
By Spencer Miller, Esq., Member.

THE APPLICABILITY OF ELECTRICAL PROPULSION TO BATTLESHIPS, TOGETHER WITH THE EXPERIENCE GAINED WITH IT ON THE JUPITER: 185
By Lieutenant S. M. Robinson, U. S. N., Member.

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Niblack, Albert P.
Nickerson, H. O.

Olcott, Alfred V. S.
Osborn, Frank H.

Page, Newman.
Paine, Cecil E.
Peck, Claude J.
Pender, Benjamin D.
Phillips, William H.
Piek, William F., Jr.
Pleasants, William H.
Powelson, Wilfred V. N.
Raven, Anton A.
Raymond, Harry H.
Raymond, James R.
Rea, Samuel.
Reuterdahl, Henry.
Richardson, Eugene M.
Richardson, Holden C.
Robins, William B.
Rodgers, William L.
Rogers, Walter H.
Ruprecht, Fritz K.
Russel, John R.
Russell, John E.

Sabin, Alvah H.
Satterlee, Herbert L.
Schafer, Charles A.
Scholz, Robert C.
Sebree, Uriel.
Shaw, Howard L.
Shaw, William.
Simpson, Robert C.
Smith, Alfred G.
Smith, Bryant R.
Smith, Robert A. C.
Smith, William A. F.
Speakman, Edward M.
Sprague, Frank J.

Taylor, Stevenson Pierce.
Thomas, Joseph D.
Thompson, Robert M.
Thorp, Harry W.
Toch, Henry M.
Todt, Edward G.
Truscott, Starr.

Van Duzer, Louis S.
Vassilieff, Dimitry.
Veit, Richard C.

Wales, Charles M.
Walker, Herbert B.

Welles, Roger, Jr.
White, George A.
Whiton, Chauncey G.
Wilkinson, Horace S.
Williams, Ralph D.
Williams, William E.
Winslow, John.
Wood, Henry A. Wise.
Wright, William L.

JUNIORS

Allen, Walter D.

Baier, Louis A.

Colby, Haldwell S.
Colley, G. A.

Hidalgo, Angel C.

Lingan, Prentiss.

Newton, G. A.

Pulsifer, Revere B.

Roundy, Caryl H.

Schmidt, John D.

Todd, J. Herbert.
Track, Frank A.

Yuan, Tsin.

ARTICLES OF INCORPORATION

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

State of New York,
City and County of New York. }

We, the subscribers, Wm. H. Webb, Chas. H. Cramp, George E. Weed, H. Taylor Gause, William T. Sampson, Horace See, Frank L. Fernald, Francis T. Bowles, Washington L. Capps, Edwin D. Morgan, George W. Quintard, Harrington Putnam and Jacob W. Miller, being persons of full age and citizens of the United States, of whom a majority—namely, William H. Webb, George E. Weed, Horace See, Edwin D. Morgan, George W. Quintard, Harrington Putnam, Frank L. Fernald, and Jacob W. Miller are citizens of and residents of and within this State, desiring to associate ourselves for scientific purposes under, and pursuant to, an Act of the State of New York providing for the incorporation of benevolent, charitable, scientific, and missionary societies, passed April 12, 1848, and the several acts amending or supplementing the same, do hereby, in accordance with the requirements thereof, certify as follows:—

First. The name of title by which the Society shall be known in law is The Society of Naval Architects and Marine Engineers.

Second. The particular business and objects of such Society are the promotion of practical and scientific knowledge in the arts of shipbuilding and marine engineering and the allied professions, and in furtherance of this object, to hold meetings for social intercourse among its members, and the reading and discussion of professional papers, and to circulate by means of publication the knowledge thus obtained.

Third. The number of directors, trustees, or managers to manage the Society shall be seven, and shall consist of a President, a Secretary, and five Members of Council.

Fourth. The names of the trustees, directors, or managers of the Society for the first year of its existence are:—President, Clement A. Griscom; Secretary, Washington L. Capps; Members of Council, Francis T. Bowles, H. Taylor Gause, Chas. H. Loring, Lewis Nixon, Harrington Putnam.

Fifth. The business of the Society is to be conducted, and its place of business and principal office is to be located, in the City and County of New York.

In Witness Whereof we have made, signed, and acknowledged this Certificate, this 28th day of April, 1893.

WILLIAM H. WEBB.
CHAS. H. CRAMP.
H. T. GAUSE.
GEORGE E. WEED.
W. T. SAMPSON.
HORACE SEE.
F. L. FERNALD.
FRANCIS T. BOWLES.
W. L. CAPPS.
E. D. MORGAN.
GEORGE W. QUINTARD.
HARRINGTON PUTNAM.
J. W. MILLER.

City and County of New York, *ss:*

On this 28th day of April, 1893, before me personally appeared William H. Webb, Charles H. Cramp, H. Taylor Gause, George E. Weed, William T. Sampson, Horace See, Frank L. Fernald, Francis T. Bowles, Washington L. Capps, and Edwin D. Morgan, to me known and known to me to be the persons described in and who executed the foregoing certificate, and severally acknowledged to me that they executed the same.

James Forrester,
Notary Public, Kings Co., Cert. N. Y. Co.

City and County of New York, *ss:*

On this 1st day of May, 1893, before me personally appeared George W. Quintard and Harrington Putnam, to me known and known to me to be the individuals described in and who executed the foregoing certificate, and they severally acknowledged to me that they executed the same.

James Forrester,
Notary Public, Kings Co., Cert. N. Y. Co.

City and County of New York, *ss:*

On this 9th day of May, 1893, before me personally appeared Jacob W. Miller, to me known and known to me to be one of the individuals described in and who executed the foregoing certificate, and he duly acknowledged to me that he executed the same.

James Forrester,
Notary Public, Kings Co., Cert. N. Y. Co.

(Endorsed.)

Upon reading the within Certificate for the Incorporation of the Society of Naval Architects and Marine Engineers, I hereby approve and consent to the incorporation thereof and the within Certificate and filing thereof, and direct that the same be filed in the office of the Clerk of the City and County of New York.

Dated New York, May 10, 1893.

Edwd. Patterson,
Justice of the Supreme Court in the State of New York
in and for the City and County of New York.

CONSTITUTION AND BY-LAWS OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

Article I.

Name and Object.

1. The name of the Association shall be "The Society of Naval Architects and Marine Engineers."

2. Its object shall be the promotion of the art of shipbuilding, commercial and naval.

3. In furtherance of this object, annual meetings shall be held for the reading and discussion of appropriate papers and interchange of professional ideas, thus making it possible to combine the results of experience and research on the part of shipbuilders, marine engineers, naval officers, yachtsmen, and those skilled in producing the material from which ships are built and equipped.

Article II.

Membership.

1. The Society shall consist of Members, Associates, Juniors, Honorary Members and Honorary Associates.

2. *Members.*—(1) The class of Members shall consist exclusively of Naval Architects, Marine and Mechanical Engineers, including Professors of Naval Architecture or Mechanical Engineering in colleges of established reputation.

(2) A candidate for this class must not be less than twenty-eignt years of age and comply with the following regulations: He shall submit to the Council a statement showing that he has been engaged in the practice of his profession, in a responsible capacity, for at least five years, and setting forth the grounds upon which he bases his claim to membership. This statement shall be signed by three Members, who shall certify to their personal knowledge of the candidate and approval of his statement.

(3) In the case of persons not American citizens, the signatures of three Members shall be required in confirmation of their personal knowledge of the candidate's scientific attainments.

(4) If three-fourths of the members of the Council present are in favor of the admission of the candidate his name shall be submitted to the Members of the Society at the next meeting; the voting to be by ballot, should a ballot be demanded.

3. *Associates.*—(1) The class of Associates shall consist of persons, who, by profession, occupation, or scientific attainments, are qualified to discuss the qualities of a ship.

(2) Candidates for this class shall submit to the Council a written statement of their qualifications for membership; this shall be signed by two Members or Associates who shall certify to their personal knowledge of the candidate and approval of his statement. If considered by three-fourths of the Council present duly qualified for associate membership their

names shall be submitted to the Society at the next meeting, to be voted upon by the Members and Associates; the voting to be by ballot, should a ballot be demanded.

4. The proportion of favorable votes for deciding the election of Members and Associates shall be at least four-fifths of the number recorded.

5. *Juniors.*—(1) The class of Juniors shall consist of graduates of technical schools of established reputation, or persons who have had not less than two years' practical experience in marine engine works or shipyards.

(2) Candidates must be at least eighteen years of age and certify their intention to continue in the profession and become naval architects or marine engineers.

(3) Juniors shall be eligible for transfer to the class of Members or Associates after fulfilling the necessary conditions; when they are twenty-eight years of age they shall be offered the option of being transferred to the class of Members or Associates in conformity with their qualifications; but if they do not accept such offer or do not qualify, they shall be dropped from the rolls of the Society.

(4) The admission of Juniors shall be by a favorable vote of three-fourths of the members of the Council present.

(5) Juniors shall have no voice in the government of the Society or admission of members.

6. *Honorary Members and Honorary Associates.*—The Council may elect Honorary Members and Honorary Associates, the total number not to exceed twenty-five. They shall be persons of acknowledged eminence in their profession upon whom the Council may see fit to confer an honorary distinction.

7. *Benefactors and Permanent Members.*—The Council may establish a list of Benefactors. It may also elect as Permanent Members of the Society such Members or Associate Members as shall, in the opinion of the Council, by reason of notably liberal contributions to the Society, merit special recognition. Permanent Members shall, from the date of their election, be relieved from annual dues, and shall have the right, subject to the approval of Council, to designate by will or otherwise, their successors. The conditions to be met before placing any name on the list of Benefactors and the regulations governing the election of Permanent Members shall be prescribed by the Council.

Article III.

Dues, Suspension and Expulsion of Members.

1. The entrance fees, payable on admission to the Society, shall be as follows:

Members and Associates, ten dollars; Juniors, five dollars; Honorary Members and Honorary Associates, no fees.

2. The annual dues shall be as follows:

Members and Associates, ten dollars; Juniors, five dollars; Honorary Members and Honorary Associates, no dues.

3. A member transferred from one grade to another shall pay the difference between the entrance fees of the two grades, and his annual dues shall be those of the grade to which transferred.

4. The annual dues shall be payable in advance on the first day of January. The Secretary shall notify each member of the amount due for the ensuing year at the time of giving

notice for the annual meeting. On notification of his election each member shall pay his entrance fee, but annual dues for the current year shall not be required unless he desires to receive the published transactions of the Society for that year, in which case he shall pay five dollars in addition to the entrance fee.

5. Members and Associates can compound for all future dues and become Life Members or Life Associates by making a single payment of two hundred dollars and signing an agreement to conform to any future amendments to the Constitution and By-Laws.

6. Members are entitled to no return of fees upon severing their connection with the Society.

7. Any member whose dues are more than three months in arrears shall be notified by the Secretary. Should his dues become six months in arrears he shall be again notified by the Secretary and his rights as a member suspended. Should his dues become one year in arrears the delinquent member shall forfeit his membership in the Society unless the Council may deem it expedient to extend the time of payment.

8. The Council may, in its discretion, temporarily suspend the annual payment of dues by any member whose circumstances have become such as to make such payment impossible, and may, under similar circumstances, remit the whole or part of dues in arrears.

9. No name shall be entered on the rolls as Member, Associate or Junior, nor shall the privileges of membership be enjoyed until the payments required in paragraphs 1 to 4 of this article have been made; if the payment be delayed for more than six months from the date of election, the same shall be void unless the Council otherwise direct.

10. (1) Should the expulsion of any member be judged expedient by five or more members, they must draw up and sign a proposal requesting such expulsion, delivering the same to the Secretary, to be laid before the Council.

(2) If the Council do not find reason to concur in the proposal, no entry thereof shall appear in the minutes, nor shall any public discussion thereon be permitted.

(3) If, however, the Council find the charges contained in the proposal for expulsion substantiated, the accused member shall be notified and given an opportunity to resign. If he avails himself of this privilege, no entry shall be made on the minutes nor public discussion of the case be permitted. But if he declines to resign and offers no satisfactory explanation of the charge, the whole case shall be submitted to a special meeting of the Society.

(4) If two-thirds of the members at this special meeting (providing there be not less than twenty present) vote for expulsion, the Chairman of the meeting shall cause the accused to be expelled from the Society, and direct the Secretary to notify the accused of this action.

Article IV.

Officers.

1. The officers of the Society shall consist of a President, Past Presidents, Honorary Vice-Presidents, twelve Vice-Presidents, twenty-four Members of Council, and a Secretary and Treasurer.

2. Both Members and Associates are eligible for the offices of President, Honorary Vice-President, Vice-President and member of Council, but three-fourths of the Council shall be Members.

3. Prior to the date of the annual meeting of the Society of the year with which the term of the President expires, the Council shall nominate a candidate for the office of President, whose name shall be presented to the Society for election at the annual meeting. Any other candidate whose nomination, signed by at least sixty Members and Associates, shall have been submitted to the Secretary prior to the annual meeting shall also be presented. The candidate receiving the highest number of votes shall be the President for the ensuing three years. The first President under this rule was elected at the annual meeting in 1906 and his term of office began January 1, 1907. The President shall not be eligible for election as his own successor.

4. (1) The term of office of the Vice-Presidents shall be three years. The terms of the Vice-Presidents which, under a previous provision of the Constitution, should have expired in 1911 and 1912 are regarded as having expired on December 31, 1911. Those terms which, under the same conditions, should have expired in 1913 and 1914 are regarded as having expired on December 31, 1912; those which should have expired in 1915 and 1916 are regarded as having expired on December 31, 1913. Beginning with the four Vice-Presidents elected for the term ending December 31, 1914, there shall be four Vice-Presidents elected each year to take the place of those whose terms expire. The Vice-Presidents to fill the vacancies occurring each year in any class shall be elected by the Council from their own membership. Retiring Vice-Presidents shall be eligible for re-election.

(2) Honorary Vice-Presidents shall be chosen from the list of Vice-Presidents who have had at least ten years' service as Vice-President. They shall be chosen at the meeting of the Council next prior to the annual general meeting of the Society and must be the unanimous choice of all members of Council present. Not more than two Vice-Presidents may be elected Honorary Vice-Presidents in any one year.

5. (1) The term of office of the Members and Associate Members of Council shall be three years. Prior to August 1 of each year the Secretary shall mail to each Member and Associate a list of the names of the Members and Associate Members of Council whose terms expire with the current year, and shall enclose a blank on which each Member may, if he so desires, nominate one additional candidate for Member of Council and one additional candidate for Associate Member of Council; and each Associate Member may, if he so desires, nominate one additional candidate for Associate Member of Council. No nominations received by the Secretary after August 31 shall be considered.

(2) Prior to September 1 of each year the President shall appoint a nominating committee of five, at least three of whom shall be Members. This committee shall scrutinize the nomination slips sent in by Members and Associates and prepare a ballot. This ballot shall contain the names of all the retiring Members and Associate Members of Council who shall not have declined re-election and a sufficient number of additional names to make a total of nine candidates for Member of Council and three candidates for Associate Member of Council. The names listed on the ballot, other than those of retiring Members and Associate Members of Council, shall be chosen by the nominating committee from those who have received the highest number of votes on the nominating lists returned by members of the Society.

(3) Should the number of names which have received at least ten votes in the case of nominees for Members of Council and five votes in the case of nominees for Associate Members of Council be insufficient to complete the number on the ballot list above provided for in sub-paragraph (2), the nominating committee shall add enough names to bring the

total on the ballot up to nine candidates for Member and three candidates for Associate Member of Council.

(4) The ballots shall be sent by mail as soon as possible after September 1 of each year to all Members and Associate Members of the Society. Each Member may vote for not more than six Members of Council and two Associate Members of Council, and each Associate may vote for not more than two Associate Members of Council. The ballots shall be returned by mail to the Secretary and canvassed by a committee of three members appointed by the President. This canvassing committee shall report the results of the election to the Council at its meeting immediately prior to the Annual Meeting of the Society.

(5) When the ballots have been sent out by the Secretary, should there be a desire on the part of Members or Associates to suggest another list of candidates for the Council, any twenty Members and Associates may unite in submitting another list to the Secretary which shall also be sent out to the membership to be considered in connection with the list already sent. In any event, the six Members who receive the highest number of votes shall be declared elected Members of Council, and the two Associates receiving the highest number of votes shall be declared elected Associate Members of Council, in each case for a term of three years.

6. A vacancy in the office of President shall be filled by ballot by the Council from the list of Past Presidents, Honorary Vice-Presidents and Vice-Presidents until the end of the year in which it occurs. At the annual meeting of that year a new President shall be elected for three years in the manner prescribed in paragraph 3. A vacancy in the office of member of Council shall be filled by the Council for the unexpired portion of the term of the Member or Associate causing the vacancy.

7. The President, Past Presidents, Honorary Vice-Presidents and Vice-Presidents shall be *ex-officio* members of Council.

8. The Council may hold meetings subject to the call of the President, as often as the interests of the Society may demand.

9. At all meetings of Council seven members shall constitute a quorum.

10. The Secretary and Treasurer shall be elected annually by the Council, but may be removed at any time by a majority vote of the Council after due notice has been given.

11. The Secretary must be a Member of the Society.

Article V.

Management.

1. (1) The President shall have general supervision over the affairs of the Society, appoint special committees, and preside at the annual general meetings. He shall be *ex-officio* member of all committees.

(2) In the absence of the President, one of the Past Presidents, Honorary Vice-Presidents or Vice-Presidents, in the order of seniority as determined by original accession to, or election in, their respective grades, shall preside and perform all the duties of the President; where there is the same date of seniority, the alphabetical order will govern. Provided, however, that for the Annual Meeting of the Society or for any other special occasion when it is known that the President cannot attend and preside, the Executive Committee shall, in its discretion, select and designate as Acting President any one of the Past Presi-

dents, Honorary Vice-Presidents, Vice-Presidents or members of Council, who shall act tor the President in his temporary absence and shall perform all the duties which would devolve upon that officer during such Annual Meeting or on such special occasion.

2. (1) The direct management of the Society shall be vested in an Executive Committee of seven, composed of five members of Council, elected annually by the Council, and the President and the Secretary of the Society *ex-officio*. At least three of the five elective members of the committee shall be Members of the Society.

(2) Meetings of the Executive Committee may be held at any time, subject to the call of the Chairman; and four members shall constitute a quorum for the transaction of any business that may be properly brought before the Committee.

3. The Executive Committee shall manage the affairs of the Society in conformity with the laws under which it is incorporated and the provisions of this Constitution. It shall direct the investment and care of the funds of the Society; make appropriations for specific purposes; arrange for the reading and publication of professional papers; take measures to advance the interests of the Society, and generally direct its affairs under such regulations as the Council may from time to time prescribe.

4. The Executive Committee shall make an annual report to the Society, transmitting the report of the Secretary and Treasurer, and of any special committee which may have been ordered.

5. (1) The Secretary shall be the Executive Officer of the Society under the immediate direction of the President and the Executive Committee.

(2) He shall prepare the business for the annual meetings and record the proceedings thereof.

(3) He shall be responsible for all expenditures and certify the accuracy of all bills or vouchers upon which money has been paid, and he shall conduct the correspondence of the Society and keep full records of the same.

6. The Treasurer shall see that all money due the Society is collected and carefully invested in such manner as the Executive Committee may direct. If considered advisable by the Council, the duties of Treasurer may be performed by the Secretary.

7. The accounts of the Secretary and Treasurer shall be audited annually in such manner as the Executive Committee may direct.

Article VI.

Meetings.

1. There shall be at least one annual general meeting of the Society for the reading and discussion of professional papers, election of officers for the ensuing year, and transaction of such other business as may be brought before it. The time and location of this meeting shall be determined by the Council at least three months prior to the date fixed.

2. Special meetings may be called by the Executive Committee at the request of twenty members, which request shall state the purpose of the meeting. The call for such meetings shall be issued ten days in advance, and shall state the purpose thereof. At these meetings thirty members shall constitute a quorum.

3. The Society may adopt, from time to time, such rules as it may think proper for the order of business at its meetings.

Article VII.

Regulations and By-Laws.

1. The Council shall have authority to establish such by-laws and regulations as may be necessary for the government of the Society in the conduct of its affairs, provided that such by-laws and regulations do not conflict with the provisions of this Constitution and that they are approved by a two-thirds vote of the members of Council present at any meeting regularly called for the consideration of same. If, however, objection be made by any member of Council to a by-law or regulation so proposed, it must be submitted in writing for the action of the entire Council and will not be finally adopted unless a majority of the Council signifies its approval.

Article VIII.

Amendments.

1. Proposed amendments to the Constitution must be reduced to writing and signed by not less than ten members. They shall be forwarded to the Secretary at least ten days before the annual general meeting, and shall be immediately forwarded to the Council for its consideration. If a majority of the Council approve the proposed amendment it shall be presented to the Society at the next ensuing general meeting for discussion; if approved by two-thirds of the members present, voting by ballot, if a ballot be demanded, it shall be adopted.

INTRODUCTORY PROCEEDINGS

TWENTY-SECOND ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

THURSDAY MORNING, DECEMBER 10, 1914.

The Twenty-Second Annual Meeting of the Society of Naval Architects and Marine Engineers was held in the Engineering Societies Building, New York City, on Thursday and Friday, December 10 and 11, 1914.

In the absence of the President, Col. Robert M. Thompson, the meeting was called to order at 10.25 o'clock by the Secretary, Mr. Daniel H. Cox.

THE SECRETARY:—The meeting will please come to order. I have to announce that, owing to the illness of our President, Col. Robert M. Thompson, whose doctors have forbidden him to leave his home, he will be unable to be present at this meeting or at the banquet. This fact was reported to the Council previous to this meeting, and at a special meeting of the Council held for the purpose, our past-president, Mr. Stevenson Taylor, was chosen presiding officer of the meeting and of the banquet.

Past-President Stevenson Taylor took the chair amid applause.

THE CHAIRMAN:—I thank you, gentlemen. Will you kindly give your attention to the Secretary-Treasurer, who will read his report, which has been adopted as the Report of the Council.

REPORT OF SECRETARY-TREASURER.

DECEMBER 9, 1914.

To the Council of The Society of Naval Architects and Marine Engineers.

GENTLEMEN:—I have the honor to submit the following report showing the condition of the Society at the close of the fiscal year ended October 31, 1914.

The membership of the Society, November 1, 1914, was as follows:—

Class of Members.	Membership November 1, 1913.	Elected at 1913 Meeting.	Promotions, Associates to Members.	Promotions, Juniors to Members.	Suspensions, by Council.	Membership at close of Annual Meeting, 1913.	Deaths, 1913-1914.	Resignations, 1913-1914.	Membership, November 1, 1914.
Members	561	30	+2	+2	11	584	3	17	564
Associates	175	32	—2	—	—	205	5	10	190
Juniors	16	2	—	—2	5	11	—	—	11
Life Members	5	—	—	—	—	5	—	—	5
Life Associates	4	—	—	—	—	4	—	—	4
Honorary Members	1	—	—	—	—	1	—	—	1
Honorary Associates	2	—	—	—	—	2	—	—	2
Totals	764	64	—	—	16	812	8	27	777

The following losses in membership occurred:—

DEATHS (8).

Members (3).

William R. Eckart.
Richard Henderson.
James G. Winship.

Associates (5).

Wilson Brown.
Thomas Dolan.
George N. Gardiner.
Gilbert N. McMillan.
Naoji Tomikawa.

Resignations (27).

Members (17).

Walter R. Addicks.
Frank L. Bigelow.
Charles H. Buckelew.
Henry Capdevielle.
Charles H. Davis.
C. Ferrand.
Francis J. French.
George M. Magruder.
Franklin C. Pahlow.
James G. Purdy.
Coleman Sellers, Jr.
George C. Shepard.
William B. Stearns.
Ogle T. Warren.
Alfred Westmacott.
Charles F. Willard.
William D. Weaver.

Associates (10).

Alva Bradley.
Edwin F. Church, Jr.
Benoist d'Azy.
John W. Duntley.
Edwin T. Douglass.
Charles W. Elphicke.
Axel E. Petre.
John J. Sullivan.
Frank B. Whitaker.
William J. J. Young.

The following delinquencies exist in the payment of dues:—

For the year ended December 31, 1910:		
Members		$15.00
For the year ended December 31, 1911:		
Members	$20.00	
Associates	40.00	
Juniors	5.00	
		65.00
For the year ended December 31, 1912:		
Members	$102.00	
Associates	115.00	
Juniors	5.00	
		222.00
For the year ended December 31, 1913:		
Members	$380.00	
Associates	250.00	
Juniors	20.00	
		650.00
For the year ending December 31, 1914:		
Members	$1,100.00	
Associates	550.00	
Juniors	25.00	
		1,675.00
Total outstanding dues at October 31, 1914		$2,627.00

FINANCIAL

Receipts.

From November 1, 1913, to October 31, 1914, inclusive.

Entrance fees of new members for the year ending December 31, 1914:		
Members and Associates	$620.00	
Juniors	10.00	
		$630.00
Dues for the year ending December 31, 1914:		
Members and Associates	$6,125.00	
Juniors	30.00	
		6,155.00
Dues for the year ended December 31, 1913:		
Members and Associates	$1,060.00	
Juniors	10.00	
		1,070.00
Dues for the year ended December 31, 1912:		
Members and Associates	$148.00	
Juniors	10.00	
		158.00
Dues for the year ended December 31, 1911:		
Members and Associates		97.00
Dues for the year ended December 31, 1910:		
Members		25.00
Members' dues in advance for the year ending December 31, 1915		40.00
Sales of publications:		
Society transactions to members and dealers	$710.00	
Special editions of papers	58.00	
		768.00
Exchange on checks, members' dues		11.72
Banquet, Annual Meeting, 1913		1,303.10
White Memorial fund		228.00
Special fund		25.00
Panama fund		1,015.00
Sale of office fittings		15.00
Interest:		
On municipal bonds, City of New York	$647.50	
On bank balances and certificates of deposit, Franklin Trust Company	129.97	
		777.47
Total receipts		$12,318.29
Balance cash in bank and on hand, November 1, 1913		1,489.70
		$13,807.99

STATEMENT.

DISBURSEMENTS.

From November 1, 1913, to October 31, 1914, inclusive.

Publications:		
Printing Volume 21	$4,160.78	
Printing Membership Year Book	88.50	
Miscellaneous printing	23.61	
Forwarding volumes and papers	45.54	
Storage of volumes	112.97	
Short settlements on foreign volumes	3.95	
		$4,435.35
Rent of safe deposit box, Franklin Trust Co		5.00
Expenses 21st annual banquet, December, 1913		1,093.10
Expenses 21st annual meeting, December, 1913		520.30
Exchange on remittances, members' dues		6.26
Salaries and clerical expenses		1,380.00
Audit of books and accounts to November 1, 1913		165.00
Rent of Society Rooms		690.00
Office expenses, postage, stationery, etc		861.68
White Memorial fund		228.00
Special fund		160.00
Investment, certificate of deposit, Franklin Trust Company		1,000.00
Total disbursements		$10,544.69
Balance cash, October 31, 1914:		
In Franklin Trust Company	$3,236.10	
On hand	27.20	
		3,263.30
		$13,807.99

Statement of Resources and Liabilities.

RESOURCES.

Membership dues after deducting for deaths and resignations ($165.00) and for doubtful accounts ($200.00)		$2,262.00
Due from dealers for volumes		577.95
Municipal bonds, at cost		12,560.00
Certificates of deposit, Franklin Trust Company		2,000.00
Office furniture and equipment at 30 per cent reduction from cost		985.00
Publications on hand at 50 per cent reduction from cost excepting volumes 18, 19, 20 and 21		4,792.19
Cash on deposit, Franklin Trust Company		3,236.10
Cash on hand		27.20
Total resources		$26,440.44

LIABILITIES.

Membership dues, paid in advance	$40.00	
Panama fund	515.00	
Volumes paid for in advance	20.00	
Total liabilities		575.00
Society's present worth at October 31, 1914		$25,865.44

The financial statements have been verified by the Universal Audit Company of New York.

Respectfully submitted,

DANIEL H. COX,
Secretary-Treasurer.

THE SECRETARY:—You all have copies of the printed report before you. The financial situation and the situation regarding membership are the important features. We come to the meeting with a larger membership than we have ever had before. That is very satisfactory. Then turn over to the page relating to our finances. With respect to the disbursements, we have been able to show some economy, mainly in the cost of the publication of the volume of Proceedings. While it is true that part of the saving, some $1,600, is due to the fact that the volume of our Proceedings is really not so expensive to publish as the preceding volume, at the same time those in charge were most careful in the expenses of publication. Another fortunate feature was that last year our banquet, instead of showing a debit, showed a credit, this being mainly due to the large attendance.

It is also satisfactory to state that from the funds received we were able to lay aside another $1,000 in the form of a certificate of deposit.

On the last page, in the statement of resources and liabilities, the first account showing the amount of dues uncollected is larger than this account was last year, the amount this year uncollected being $2,262 as against about $1,700 last year. I may say that this statement is usually made up as of November 1, and since that time we have collected $550, which leaves the balance of uncollected dues about normal, and about the same amount as last year.

The cash balance on hand this year, as of November 1, was $3,236.10, which is $1,400 larger than last year at the same time.

Under the head of "Liabilities" one account requires explanation, namely, the Panama fund, in which we show a liability of $515. This is explained by the fact that during the current year we have received from the membership at large, as shown under the heading of "Receipts," the sum of $1,015, to be applied towards the guarantee fund of $2,000, the amount to which our Society obligated itself in connection with the possible expenses at San Francisco. Last year, before we had received any fund for the purpose from the members of the Society, the amount of $500 was contributed by authority of the Council to those in San Francisco, so that this liability of $515 is the difference between the amount actually collected, namely, $1,015, and the amount of $500 that has already been forwarded for that purpose.

With these explanations, I think the report is quite clear.

THE CHAIRMAN:—Gentlemen, you have heard the report of the Secretary-Treasurer. What is your pleasure?

On motion, duly seconded, the report was adopted.

THE CHAIRMAN:—We will now proceed to the next item in order. Will the gentlemen rise—IN MEMORIAM. The Secretary will read the list of the names of those who have passed away during the past year.

The Secretary read the list of names of deceased members while the members present stood.

THE CHAIRMAN:—The next business in order is the announcement of the election of Members of Council, Associate Members of Council, Vice-Presidents, Executive Committee, Secretary-Treasurer, etc.

I have the pleasure of announcing to you that the ballots cast by the Members of the Society resulted in the election, as Members of the Council for the term expiring December 31, 1917, of the following gentlemen:—J. E. Denton, D. H. Cox, H. L. Ferguson, C. H. Peabody, F. L. DuBosque, and H. C. Sadler.

As Associate Members of Council for term expiring December 31, 1917:—H. S. Grove and H. L. Aldrich.

As Vice-Presidents for the term expiring December 31, 1917:—W. I. Babcock, W. L. Capps, W. F. Durand, and D. W. Taylor.

As Members of the Executive Committee for the ensuing year:—Stevenson Taylor, W. L. Capps, Lewis Nixon, W. I. Babcock, and Andrew Fletcher.

For Secretary-Treasurer for the ensuing year, Daniel H. Cox.

For the Committee on Papers for the ensuing year:—W. M. McFarland, W. I. Babcock, and F. L. DuBosque.

The Secretary will now read the list of new members elected.

The Secretary:—At the Council meeting held yesterday, the following-named applicants for members of various grades and transfers from one grade to another were acted upon and were favorably reported to the Society:—

Members (28).

Albert Allen, Surveyor, Lloyd's Register, 17 Battery Place, New York, N. Y.

Wilmon H. Benson, Superintendent, Hull Construction, Newport News Shipbuilding and Dry Dock Co., Newport News, Va.

T. Bingley F. Benson, Naval Architect, 205 Yonge Street, Toronto, Canada.

Manuel I. Bianchi, Naval Constructor, Argentine Navy, 97 Butler Road, Quincy, Mass.

William H. Blakeman, Assistant to General Superintendent, Wm. Cramp & Sons Ship and Engine Building Co., Philadelphia, Pa.

Joseph Barraja-Frauenfelder, Chief Engineer, Lake Torpedo Boat Co., Bridgeport, Conn.

Charles N. Crowell, General Manager, Grand Trunk Pacific Dry Docks and Ship Repair Co., Box 126, Prince Rupert, B. C.

Sloan Danenhower, New York Representative, Lake Torpedo Boat Co., 50 Church Street, New York, N. Y.

George A. Dean, Jr., General Superintendent, Spedden Shipbuilding Co., 21 W. Franklin Street, Baltimore, Md.

Archibald Denny, Shipbuilder, Wm. Denny & Bro., Dumbarton, Scotland.

Maurice E. Denny, Shipbuilder, Wm. Denny & Bro., Dumbarton, Scotland.

Harry J. Hartridge, Assistant Superintending Engineer, American Hawaiian Steamship Co., 248 78th Street, Brooklyn, N. Y.

Robert L. Hague, Naval Architect, Standard Oil Co., 2788 Sacramento Street, San Francisco, Cal.

Charles J. Hudson, Surveyor, Lloyd's Register, 103 79th Street, Brooklyn, N. Y.

Joseph W. Isherwood, Naval Architect, 4 Lloyds Avenue, London, E. C.

John Hudson, Superintending Engineer, United Fruit Co., 404 61st Street, Brooklyn, N. Y.

A. W. Carmichael, Assistant Naval Constructor, U. S. Navy, Navy Yard, Norfolk, Va.

Norman E. McClelland, Surveyor, Lloyd's Register, 17 Battery Place, New York, N. Y.

Philip L. Miller, General Manager, Canadian Vickers Co., Ltd., Longue Pointe, Montreal.

Robert W. Morrell, Assistant Superintendent, Atlantic Basin Iron Works, 39 Water Street, New York, N. Y.

Herbert N. Perham, Lieutenant, U. S. R. C. S., Seneca, Tompkinsville, N. Y.

Edward S. Robinson, Erecting Department, Westinghouse Machine Co., East Pittsburgh, Pa.

George B. Turnbull, Chief Engineer, Great Lakes Engineering Works, Detroit, Mich.

Joseph J. Tynan, Vice-President, Union Iron Works, San Francisco, Cal.

George B. Ward, Draughtsman, Chief Engineer's Office, Panama Canal, Cristobal, Canal Zone.

James C. Workman, Chief Engineer, American Shipbuilding Co., Cleveland, Ohio.

Henry B. Oatley, Chief Engineer, Locomotive Superheater Co., 30 Church Street, New York, N. Y.

Nicholas J. Pluymert, Jr., Naval Architect, Standard Oil Co., 26 Broadway, New York, N. Y.

Associate to Member (2).

Martin L. Katzenstein, Manager, Marine Department, International Steam Pump Co., 115 Broadway, New York, N. Y.

James H. B. MacKenzie, Consulting Engineer, 24 Stone Street, New York, N. Y.

Junior to Member (1).

Ralph T. Hanson, Assistant Naval Constructor, U. S. Navy, Navy Yard, Charleston, S. C.

Associates (7).

John H. Bernhard, 244 West 104th Street, New York, N. Y.

Henry E. Caband, General Agent, N. Y. & Cuba Mail Steamship Co., Pier 14, East River, New York, N. Y.

Edward R. Grabow, General Manager, United Fruit Co., 33 Commonwealth Avenue, Boston, Mass.

Henry Reuterdahl, Marine Artist.

John E. Russell, President, Thor Iron Works, Ltd., Toronto, Canada.

Bryant R. Smith, Ship Draughtsman, Navy Yard, Mare Island, Cal.

Charles L. Cook, President, C. Lee Cook Manufacturing Co., Louisville, Ky.

Juniors (3).

Prentiss Lingnan, Draughtsman, Lake Torpedo Boat Co., Bridgeport, Conn.

J. Herbert Todd, Student, Stevens Institute. Address, 139 Rutland Road, Brooklyn, N. Y.

Tsin Yuan, Student, Naval Architecture, 99 St. Botolph Street, Boston, Mass.

THE CHAIRMAN:—These gentlemen are declared to be elected members of the Society by the Council, provided the Society endorses such election. The matter is now before you for action. You are entitled to demand a ballot. If any of you wish it, I will order a ballot taken. If not, a motion to approve the action of the Council admitting these gentlemen as Members, Associate Members, etc., will be in order.

On motion, the action of the Council was approved.

THE CHAIRMAN:—These gentlemen are now members of the Society in the respective grades to which they have been elected. The Secretary's order of exercises now calls for the President's address.

Chairman Taylor then presented the following address:—

It is my extreme regret that, owing to his illness, President Thompson cannot preside at this meeting of The Society of Naval Architects and Marine Engineers. I thought two years ago that having completed my term of office I had finally graduated from this platform. Your Council has decreed otherwise, so in deference to their wish here I am, with the consoling thought that I am less likely to get into mischief on the platform than on the floor.

The annual report of your Council has been distributed, and, as the report gives you full information concerning the Society, further comment at this time is unnecessary.

As to the progress during the past year in naval architecture and marine engineering, more particularly the latter, it is interesting to note that the number of commercial seagoing vessels provided with Diesel and other oil engines for motive power has increased somewhat, so that now there are one hundred or more, the largest installation being one of 4,000 horse-power with six cylinders on each of two shafts. A much greater development has taken place in the method of propulsion by the system of geared turbines, combining the efficiencies of the high-speed turbines with that of the comparatively moderate revolutions of the best propeller wheels. According to the latest report the number of war, passenger and cargo vessels now built or building with all-geared or part-geared turbine machinery is 126, with a total of about 1,000,000 horse-power. Sixty-two of these vessels, with a total of 620,000 horse-power, have been ordered during the last year. The horse-power being transmitted through one line of shafting by means of gearing is now up to 20,000. The electrical propulsion of vessels, strictly an American idea, is progressing, and the installation of the same in a battleship is contemplated, as will be noted from one of the interesting papers presented at this meeting.

During the past four months the submarine, the aeroplane, hydroplane and dirigible airship have proved their importance in time of war.

It is about thirty years since J. P. Holland designed his first submarine, which was constructed by the De Lamater Iron Works of this city at the foot of West 13th Street. It was cigar-shaped, about 75 feet long, and 12 feet diameter in the center, a mere cockle-shell compared to the submarine of this day which the wonderful improvements in motive power have made possible. I well remember seeing this submarine submerged alongside the wharf, but held by the slings of a derrick to make sure it would come to the surface when required. It is almost as many years since Simon Lake commenced building his sub-

marines. The submarine of the present day is quite a different vessel. There are now under construction large submarines capable of steaming 20 knots on the surface, developing 5,000 horse-power, with a combination of boilers with oil fuel and turbine-geared machinery.

The two-cycle Diesel engine is also still used for surface running, while the storage battery remains the driving power while submerged. The new submarines will encompass a radius of from 3,000 to 4,000 miles on the surface and from 120 to 150 miles submerged.

The submarine has proven its efficiency for a certain phase of warfare, but that it has removed the use of the battleship entirely from the field remains to be seen. Possibly the effect of the submarine may change the construction of battleships and cause a reduction in the size of the units.

Captain Baldwin, a well-known American aviator, has recently published an interesting article written before, but proven correct since the commencement of the war in Europe, clearly showing the great advance abroad in the art of navigating the air, an advance so much beyond that of the United States that one wonders if we are not losing our reputation for foresight, enterprise and ingenuity. This is more remarkable when we remember that the aeroplane was developed and made really successful in this country by two Americans, the Wright brothers, who have not received the same recognition here that they have in England and France.

The loss of the steamship Titanic, supposedly the finest vessel of the time, in April, 1912, on her first voyage to New York, aroused the maritime world, resulting in a call originating in this country for an International Conference on Safety of Life at Sea.

The Convention was held in London, opening November 12, 1913, the text of same being finally signed on January 20, 1914. Germany, Austria, Bohemia and Hungary, Belgium, Denmark, Spain, France, Great Britain, Ireland, and the Colonies of Australia, Canada and New Zealand, Italy, Norway, The Netherlands, Russia, Sweden, and the United States were in all represented by fifty-five delegates. The President of the United States appointed ten delegates, of whom five are members of this Society, though they were not appointed as such. It is a matter of gratification, however, that one of the founders of this Society and a distinguished officer and member of the Council since its incorporation, Admiral W. L. Capps, was selected by the Convention to be chairman of its most important committee, the one on Construction, involving particularly the bulkheads and subdivision of ships. It is needless to say that every member of the delegation worked faithfully to procure the results sought by the Convention and to bring into one accord the many varied interests involved.

It is much to be regretted that the text of the Convention was not at once ratified by the United States Senate.

The one great event of the world, overwhelming all others, is the horrible calamity of the almost universal war in Europe. Several nations are engaged in a conflict never before equalled. Each particular nation disavows all responsibility. The people of each nation involved, if accounts be true, and there seems to be no reason for doubting them, have entered the war with a consecration in itself worthy of admiration. Every one of you has his own opinion of the causes, responsibility and probable outcome, which without doubt may be known for the asking. This being a Society devoted to science, it were better to avoid partisanship, but I will venture to say that all will agree with the reported opinion of a prince of a royal family of great renown, that "this war is useless, senseless and unnecessary."

On our roll of membership are the names of distinguished men from every one of the

nations engaged in conflict, and to discuss the subject other than from the scientific standpoint would be apt to cause bitter thoughts and remarks which we have no desire to arouse.

The daily press has published columns from the pens of noted men of affairs on the advisability of preparedness and of unpreparedness for war.

Without going deeply into these subjects, it would seem that so long as national racial tendencies exist and desires for empire supposedly for the interest of the citizens of each nation, tendencies and desires that develop the consecration and patriotism so pre-eminently shown at present in Europe, just so long will there be battleships, airships, submarines and all of the other dreadful paraphernalia of conflict in which as naval architects and marine engineers we must be interested. The old contest of guns versus armor will be accompanied by the newer conflicts of airships and submarines versus battleships, cruisers, destroyers and the like. We would very much prefer to devote the greater part of our energy, skill and industry in building up a merchant marine worthy of our great country, but until a world agreement can be reached, and made absolutely perpetual, to abandon these other implements, be they for war or protection against war, this country must have its share, and you who design, construct and operate the same must keep in touch with their developments and must be able to produce in the future, as in the past, the best of each class.

Your President in his address at the 1910 meeting in brief said:—"Some day * * * the people of this great nation * * * will realize the supreme importance of having ships and yards in which to build them; will realize that we are deliberately passing to foreigners annually enormous sums which should be earned by our own citizens; and they will come to themselves, will unite on the right course, will demand from their representatives a change from the present condition, and they will get it." He then had no thought of the condition of affairs now existing. The great European war accomplished in one short month what years of debate in and out of Congress failed to accomplish. It brought directly to the personal interest of agriculturists and some manufacturers the great need for them of a merchant marine; and over-night almost there was a great demand for American ships which the futile legislation of years past had failed to provide.

So great has this demand been during the past few months that hasty legislation of various kinds has been proposed, and some enacted.

The rider to the Act of August 12, 1912, passed for the management of the Panama Canal and the government of the Panama Zone, permitted under certain conditions the admission of foreign-built vessels to American registry for trade with foreign countries.

No owners of such vessels took advantage of this opportunity to come under the American flag, for the simple reason that our other laws and customs compel a much greater cost of operation under the American flag than that of any other nation.

On August 18, 1914, an amendment to the Panama Canal Act just mentioned was passed changing the conditions of that Act and authorizing the President in his discretion to suspend the provisions regarding the nationality of watch officers and the requirements of survey, inspection and measurement.

This amendment practically went into effect on September 8, and since that date the dangers of war have caused ninety-seven vessels of 339,153 gross tonnage to be transferred from foreign to American registry. These vessels, owned by American corporations or individuals, were previously built and operated under foreign flags because of the much less cost of so doing.

Whether these vessels and others that follow their example will remain under the Amer-

ican flag will naturally depend largely on the laws which will be in force "when this cruel war is over."

The prominent propositions which have yet to be acted upon are the purchase of foreign vessels, some of which are now interned in our own seaports; and the formation of a steamship corporation to operate so-called American ships in the trade of the world, either scheme to be supported entirely or in a great measure by the United States Government.

The President of the United States in his message to Congress just convened says that to "correct the many mistakes by which we have discouraged and all but destroyed the merchant marine of the country, to retrace the steps by which we have, it seems almost deliberately, withdrawn our flag from the seas, would take a long time and involve many detailed items of legislation." Also in reference to the pending Shipping Bill he says:—"In my judgment such legislation is imperatively needed and cannot wisely be postponed. The Government must open these gates of trade and open them wide; open them before it is altogether profitable to open them or altogether reasonable to ask private capital to open them at a venture."

These words would be very encouraging if they did not indicate government ownership and operation, our experience in which does not make us enthusiastic. Government ownership has not proven better than private enterprise by any means. Those who have used government owned and controlled telephone and railroad systems abroad know how they compare with these systems in the United States.

In this we have the corroborative opinion of M. Yves Guyot, President of Societe d'Economique Politique and former Minister of Public Works in Paris, who has recently published his views on this subject in "When and Why Public Ownership Has Failed."

I quote a sentence or two:—"Individuals are industrious, productive and economical; but administrative and political groups, both national and municipal, are wasteful and run the taxpayers into debt." Again, "Men in office do this or that as the first consideration according to what will make the broadest appeal to present popular prejudices and sympathies and further expenditures with a certain audacity which please better than those which do not appeal to public imagination."

Like American travelers, M. Guyot criticizes such of the railroads in France, Germany, Belgium and Austria as are owned by the governments and shows an advantage to the public in the railroads of these same countries that are operated by private corporations.

Now government operation of ships can only be performed with a disregard of original cost and the regular overhead charges which must in any event be met.

The actual cost of building and operating steamers under the United States laws according to published figures is at least 40 per cent higher than under the English or German flag, and even more under the flags of some other nations; and if the United States Government builds the vessels for our merchant marine, it is certain that the specifications and inspection will make the cost much higher. This great difference cannot be met by earnings, and of course there will be no profit. The taxpayers will pay the bill, making such expenditures practically a subsidy in disguise.

There are difficulties in bringing about the re-establishment of a merchant marine so long neglected. The Civil War practically destroyed what was then left of American lines to foreign countries, as the capacity of our shipyards was required for naval purposes. At the same time advantage of the change from wood to iron for hulls was taken by those abroad, particularly by English shipbuilders, who made great strides forward. Our own coun-

try needed all available capital and still needs more for interior development, so shipbuilding has been abandoned by capital for the more profitable railroad building and manufacturing. All manufactures have been protected, and that protection made the cost of all labor and materials used in the building of ships much greater than the cost abroad.

Our agriculturists, so many of whom are far from sight of the sea, cared nothing for American ships. They have been content to allow foreigners to carry their goods until the foreigners have gotten so far ahead that they will be difficult to overtake in the race. Our standards of living have been raised for everybody, but particularly for those who work for daily or monthly wages. Mechanics of all classes have received great increases in wages.

These changes in fifty years have combined to cause neglect of an American merchant marine.

A change in our laws, removing some restrictions and regulations, would put the operation of our steamships on the same level as those of foreigners; but the political tendencies of recent years, the evident disposition of legislators to enact class legislation like that of the LaFollette Seamen's Bill, will surely add to the cost of operating vessels already too expensive to compete with foreigners and makes such a change improbable. The free ship proposition so boldly advocated has proven an absolute failure. Not one ship came under our flag under that proposition, until, as I have previously pointed out, the ninety-seven were driven by the European war to come under its protection. All other suggestions have been from time to time defeated or tabled by Congress, and for this no one political party can be held responsible.

Now the fact remains, regardless of those who hold to the contrary, that British supremacy was started and has been upheld by subsidies while the United States was busy in other directions and supinely allowed our commerce to be taken over by them and others. The British Government has given an example of this by loaning to the Cunard S. S. Company at two per cent interest per annum sufficient money to build the Lusitania and Mauretania to hold the supremacy of the passenger trade, and to provide vessels for their naval reserve. Germany in twenty-five years has made an enormous advance in her merchant marine. That she would do less to accomplish this result than Great Britain is unbelievable. Japan furnishes another distinguished example of what can be done by a government for its merchant marine.

We must have a merchant marine. We need hardly revert to the well-known instances of our deficiency. Our admirable navy, to be compared to the great navies of the world, must have ships to serve as auxiliaries, as tenders and transports, and as schools for mariners.

Imagine if you can the United Kingdom's situation during the past few months were she not provided with ample ships most skilfully handled; and what would be even now the condition of our own agriculturists and manufacturers were it not for the ships of other nations, mostly British.

Our agriculturists and manufacturers must have ships to carry their products to foreign markets, ships under the American flag, for it is truly said that "Trade follows the Flag!"

Why not follow the example of other nations? We cannot grant subsidies, that word is so objectionable, but we may grant direct aid, based on service, on increased cost of operation due to the high standards set by our own people; the carrying of mails or the need of a naval reserve by the loan of large sums at low rate of interest; by preferential or differential duties; by a combination of these reasons or without any of them, but solely for the broader and better reason that our country needs a merchant marine, not any particular section or class but the whole country and all classes north and south, east and west.

THE CHAIRMAN:—We will now call for the Report of the Committee on Revision of the Constitution and By-Laws.

THE SECRETARY:—About a year ago, appreciating that, owing to certain amendments that had been made and others that had been suggested to meet certain contingencies which have arisen since the original Constitution and By-Laws were framed, it was desirable that there should be a revision of the Constitution and By-Laws, the Council appointed a committee with Admiral Capps as chairman, Captain McAllister and the Secretary as members, directing this committee to consult together, and with the members of the Society, with the intention of revising the Constitution and By-Laws, not merely making amendments to them, but taking advantage of any suggested amendments which have been proposed or difficulties which have been met with in the handling of the Society's affairs. This committee was directed to report back to the Council as soon as possible so that its efforts could there be passed upon, the changes it proposed be considered, and the matter presented in final form to this meeting of the Society.

The Committee considered the matter most carefully, reported to the Council, and at two meetings the action of the Committee has been unanimously ratified by Members of Council present; you have before you now in printed form the revised proof of the Constitution and By-Laws which takes into account all of the suggestions, amendments and revisions recommended by this special committee. With regard to amendments to the Constitution, our present Constitution and By-Laws provide as follows:—

"Proposed amendments to the Constitution must be reduced to writing and signed by not less than ten members. They shall be forwarded to the Secretary at least ten days before the annual general meeting, and shall be immediately forwarded to the Council for its consideration. If a majority of the Council approve the proposed amendment, it shall be presented to the Society at the next general meeting for discussion; if approved by two-thirds of the members present, voting by ballot, if a ballot be demanded, it shall be adopted."

These formalities have been gone through with, so that the entire matter not only has the approval of all of the Members of Council who have been consulted, but it is in legal shape to be acted on this morning.

Running over the matter so that the membership at large may grasp it, the scheme, as already announced, was that this is to be the proof of the revised Constitution and By-Laws, if accepted by the Society. All alterations from the previous Constitution are shown in italics, so by glancing from page to page you can see in what respects the original Constitution is to be amended.

The main points which were called to the Committee's attention, outside of merely typographical errors and inconsistencies which had crept in, were: First, there has been complaint on the part of members, when elected, that they were called upon not only for their entrance fee but the dues for the year in which they were elected, and as, owing to the change in date of meeting, they were elected in December and not notified until about the middle of December, it hardly seemed proper that they should be called upon to pay the dues for the year in which they were elected. The intention of that requirement was

that such dues should apply toward the cost of the current volume of Proceedings, but the Committee, as you will see, has adjusted that matter in a way which seems fair.

Another matter was the election of Members of Council, how the ballot should be prepared; another subject was the question of presiding officers at the meetings; another one created an additional class of members under the heading of "Benefactors and Permanent Members." Running through quickly: outside of the merely typographical or unimportant changes, the first main point is the establishment of the grade of "Benefactors and Permanent Members." It was thought that any one who contributed very largely to the Society or who was of special service to it should be placed in some distinctive position, and this grade of membership takes care of that situation. The question of the dues for the year of election is made quite clear. The changed part says:—

"On notification of his election each member shall pay his entrance fee, but annual dues for the current year shall not be required unless he desires to receive the published Transactions of the Society for that year, in which case he shall pay Five dollars ($5.00) in addition to the entrance fee."

That gives the member a reason for charging anything, if anything is charged. There is practically an entire revision of the scheme of preparing the ballot for the election of Members of Council and Associate Members of Council who are to be elected annually.

To briefly describe the method now proposed, it is that in the beginning each member of the Society is invited by the Secretary to make his suggestions as to candidates for Members of Council and Associate Members of Council. Then a nominating committee is formed, as it was formed before, by the Council, and that committee considers such suggestions of the individual members as may be made. Then a ticket is printed, taking account of these suggestions and the Committee's authority, and this ticket is sent out to all the membership. In addition to that, even after this ticket has been prepared after consultation with the Society at large, if there be any objection to the ticket means are provided for making an alternate ticket; in other words, the whole method is very broad and clear.

With this explanation, the matter is in the hands of the Society, such other changes as have been made being relatively unimportant.

The Chairman:—According to our present Constitution, with respect to amendments to the Constitution—and this is practically an amendment to the whole Constitution—it is provided, "If a majority of the Council approves the proposed amendment, it shall be presented to the Society at the next ensuing general meeting for discussion." The Council has approved this revision of the Constitution and By-Laws unanimously. The present Constitution further provides:—"If approved by two-thirds of the members present, voting by ballot, if a ballot be demanded, it shall be adopted." Is a ballot demanded? If not, a motion to approve the revised Constitution and By-Laws is in order.

Mr. H. L. Aldrich:—I move that the revised Constitution and By-Laws be approved.

The motion was duly seconded, put to vote, and carried.

THE CHAIRMAN:—The revised Constitution and By-Laws goes immediately into effect. The Secretary has some details to which he wishes to call attention.

THE SECRETARY:—The matter of the advisability of the establishment of an endowment fund was discussed last year, and a committee appointed to go into the matter thoroughly. This committee has considered the matter very carefully and has made a report to the Council. I may say that this matter of endowment funds or other matters relating to the administration of the funds of the Society are really in the hands of the Executive Committee and the Council, but they naturally wish the Society at large to take action on matters of such importance as this.

The report of the Committee is rather long, but at a meeting of the Council yesterday afternoon, after having read the Report of the Committee on Endowment, it was unanimously voted to adopt the following suggestions of that committee. These suggestions are at the end of the report of the committee, and are as follows:—

"Therefore, although it is not advisable at this time to press for immediate additional contributions to an endowment fund, a definite beginning should be made and the following procedure is recommended:—

"1. That the accumulated funds of the Society, at least to the extent of $12,560 now invested in municipal bonds, be immediately set aside as the nucleus of an endowment fund.

"2. That all entrance, Life and Permanent Membership fees, all gifts, bequests, etc., unless otherwise specifically designated, be set aside and invested as a permanent addition to the endowment fund.

"3. That until the endowment fund reaches the sum of $25,000, not more than one-half of the annual income from it may be used for the current expenses of the Society, and that at least one-half of the said annual income shall be set aside and invested as an addition to the endowment fund.

"4. That after the endowment fund reaches the sum of $25,000, two-thirds of the income therefrom may be used for the current needs of the Society, the remaining one-third to be set aside for investment as an addition to the endowment until this fund amounts to $50,000. That thereafter the whole of the income from the endowment fund may be used in such manner as the Council may direct, increases in the principal sum thereof to be provided for by investment of all entrance, Life and Permanent Membership fees, etc., as noted in paragraph 2 above."

THE CHAIRMAN:—There is no action for the Society to take on this matter at this time.

THE SECRETARY:—I may say that the Secretary received yesterday, not in time to incorporate in the annual report, one additional Life Member, Admiral W. L. Capps.

THE CHAIRMAN:—The Secretary will read a letter received in regard to a memorial to the late Alfred Noble, with a request that it be presented to our members.

The Secretary read the following:—

"American Society of Civil Engineers.

"220 West Fifty-Seventh St., New York.
July 1, 1914.

"ALFRED NOBLE MEMORIAL.

"Mr. Daniel H. Cox,
Secy.-Treas. Society of Naval Architects and Marine Engineers.

"Dear Sir:—

"At a meeting of the Board of Direction of the American Society of Civil Engineers, June 2, 1914, the following was adopted unanimously:—

"Whereas, by the death of Alfred Noble the engineering profession in America has lost its most prominent member; and

"Whereas, Mr. Noble has been connected with this Society for forty years, and has served upon its Board of Directors for nine years, as Director, Vice-President, President, and finally as Past-President; be it

"Resolved, That the Board of Direction of the American Society of Civil Engineers acknowledges the indebtedness of the profession to this wise counselor, and active and tireless worker, who, during his connection with this Board and subsequently, gave ungrudgingly and unselfishly so much of his valuable time for the general good; and be it further

"Resolved, That the Board desires to spread upon its records its sense of profound sorrow in the great less, not only to the profession of engineering, but to the world, of one who by his strong and intellectual personality, earnestness of purpose, sterling honesty, and great heart, has set an example for engineers of the future, and in so doing endeared himself to all with whom he came in contact.

"At the same meeting the Board considered the advisability of the erection of a permanent Memorial to Alfred Noble, and, in the belief that such recognition of the man, of the engineer, and of the profession will meet with universal approval, decided that such a memorial is desirable, should be inaugurated by this Society, and should be on no small scale. It was also decided that the engineers of the world be asked to subscribe to the funds necessary for this purpose, and that the memorial take the form of an appropriate statue to be erected in some suitable location.

"It was the view of the Board that, inasmuch as Alfred Noble's professional practice was national in character, that he was an adviser of Presidents, and consulted on some of the mose important engineering work of the country, the capital of the nation is the proper location for such a memorial, and that the Congress be requested to provide a suitable site in the city of Washington.

"The Board set aside the sum of $1,000 as a first subscription towards the necessary funds, and appointed the following committee with power to carry out the project:—

Onward Bates, Chicago, Ill., Chairman.
Robert Moore, St. Louis, Missouri.
Samuel Rea, Philadelphia, Pa.
Samuel H. Hedges, Seattle, Wash.
F. H. Newell, Washington, D. C.
Charles Warren Hunt, New York City, Secretary.

"This Committee fully realizes the importance of the duty with which it has been charged, and calls attention to the fact that, notwithstanding the great debt of civilization to the engineer, no dignified and permanent monument in recognition of the work of the profession has as yet been erected in the United States, and to the opportunity which the universal recognition of the pre-eminence of this engineer presents for adequate expression.

"The Committee desires to enlist your present sympathy in the movement and your future aid in carrying it out by bringing it to the attention of the members of your organization whenever the details have been so far worked out that they may be laid before you.

"Yours respectfully, for the Committee,

CHARLES WARREN HUNT,
Secretary."

THE CHAIRMAN:—There is no action needed at the present time on this letter. It is merely presented to you in accordance with the request of Mr. Hunt.

The reading of papers is now in order, and I call for the reading of the first paper before the meeting, No. 1, entitled, "International Conference on Safety of Life at Sea," by E. T. Chamberlain, Esq., Honorary Associate. Is Mr. Chamberlain present, or is there any special representative of Mr. Chamberlain here? If not, Prof. Herbert C. Sadler will read the paper.

Professor Sadler read the paper.

INTERNATIONAL CONFERENCE ON SAFETY OF LIFE AT SEA.

By E. T. Chamberlain, Esq., Honorary Associate.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

The International Conference on Safety of Life at Sea assembled at London on November 12, 1913, and ended its labors on January 20, 1914, when accredited representatives of the thirteen principal powers signed the most comprehensive international agreement relating to the merchant marine which has ever been effected.

Even the casual student of the history of American diplomacy will find satisfaction in the attainment of an agreement which so fully accords with the principles of benevolence, freedom and reciprocity enunciated in respect of maritime commerce by Benjamin Franklin and other fathers of the republic and since consistently followed, with but slight deviations through temporary causes, as the permanent maritime policy of the United States.

To American commerce and industry such an international agreement is of large and direct value. During this summer all forms of gainful occupation in America have had brought home to them the measure of their dependence, hitherto unappreciated, upon the freedom of ocean transportation. What the shock of war, temporarily shutting up in harbors the ships which conduct our international exchanges, has done on a vast scale, in a lesser degree conflicting maritime regulations by different nations also effect in delay and obstruction to commerce. Every year, under normal conditions, two million passengers, in round numbers, cross the Atlantic between the United States and Europe, much more than half of whom are either our own citizens or those who come to make our country their permanent home. Measures, accordingly, such as the conference incorporated into the International Convention on Safety of Life at Sea, intimately affect the peace and happiness of homes throughout the United States. The London Conference and its conclusions are of special interest to the Society of Naval Architects and Marine Engineers. The influence which the United States exerted in shaping the conclusions of the conference was due in a large measure to the helpful co-operation of the Society of Naval Architects and Marine Engineers in the work of preparation in this country for the conference and to the active work of six of its members who constituted a majority of the American delegation. The more difficult subjects treated in the Convention relate directly to the technical work of many members of the Society, and these, I understand, will be discussed in other papers at the annual meeting.

In the order of their signature to the Convention, which was executed in the French language, Germany, Austria-Hungary, Belgium, Denmark, Spain, the

United States, France, Great Britain, Italy, Norway, the Netherlands, Russia and Sweden participated in the conference. Before the conference was called, the United States and Germany united in the request to the British Government that the Australian Commonwealth, the Dominion of Canada, and New Zealand be invited to attend the conference as self-governing British dominions, with independent delegations. Accordingly, fifteen delegations enjoyed plenary powers, while Norway's delegation was sent *ad referendum.* Japan, which had been unable to make the necessary preliminary studies, was represented from the Embassy staff at London for purposes of observation and study. The conference consisted of ninety-six delegates and technical advisers with eighteen secretaries, some of whom gave the benefit of technical training and long experience to their delegations.

It was evident at the outset that so large an assemblage could not discuss in detail the many and intricate questions on the programme, and, accordingly, the work was divided among six committees under the heads, respectively, of Safety of Navigation, Construction, Certificates, Radiotelegraphy, Lifesaving Appliances, and Revision, each nation being represented on each committee by one or more delegates. Chief Constructor Washington Lee Capps, U. S. N., was chairman of the important Committee on Construction. A seventh committee was organized informally, comprising Lord Mersey, President of the Conference, the chairman of the six committees, and two or three other members, to determine questions of jurisdiction between the committees, to consider matters not properly within the province of any committee and, in general, to act as a steering committee. These committees held one hundred and thirty-three meetings during the seven weeks of unremitting work of the conference. Besides these meetings, the delegations of each nation, of course, held separate meetings for the purpose of determining the policy of each delegation as questions arose on which the delegations had not reached conclusions before the conference assembled. In many instances, of course, delegations modified conclusions in order to promote ultimate agreement.

In respect of preparation before the conference, the British, French, and German delegations were better equipped than the delegation from any other nation. The governments of these three countries more than a year before the conference met had provided ample means and facilities for the study of the more important subjects by committees of men of the highest training, and each of these delegations entered the conference with more less matured views as to the policy to be pursued on larger questions. An effort, undertaken three times, to secure from Congress sanction and means for similar preparation in the United States, was not successful. It was necessary, therefore, to organize in this country committees composed entirely of officers in the various departments more or less directly concerned with the administration of laws upon the subjects to be taken up at the conference. In this work the Society of Naval Architects and Marine Engineers was invited to help, and it may be stated here that should the Convention be ratified by the Senate of the United States, the co-operation of the Society will be needed in the framing of laws to give effect to the Convention.

The foundation of the International Convention on Safety of Life at Sea is the Safety Certificate and the international attributes bestowed upon it. By this certificate the nation which issues it certifies that after inspection and survey the vessel which carries it complies in an efficient manner with the requirements of the Convention. In every case the government which issues the Safety Certificate is bound by the Convention fully to guarantee the completeness and efficiency of the inspection and survey. Articles 60 and 61 of the Convention read as follows:—

"ARTICLE 60.

"The Safety Certificate issued under the authority of a Contracting State shall be accepted by the governments of the other Contracting States for all purposes covered by this Convention. It shall be regarded by the governments of the other Contracting States as having the same force as the certificates issued by them to their own vessels.

"ARTICLE 61.

"Every vessel holding a Safety Certificate issued by the officers of the Contracting State to which it belongs, or by persons duly authorized by that state, is subject in the ports of the other Contracting States to control by officers duly authorized by their governments in so far as this control is directed towards verifying that there is on board a valid Safety Certificate, and, if necessary, that the conditions of the vessel's seaworthiness correspond substantially with the particulars of that certificate; that is to say, so that the vessel can proceed to sea without danger to the passengers and the crew."

To appreciate the great benefit to international commerce by sea and to shipbuilding and shipowning which these two articles will confer it must be borne in mind that hitherto there have been no rules of the law of nations for the safety of ocean travel. The aim of the London Conference above all else was to demonstrate the willingness and ability of nations to agree upon standards of safety for ocean travel, then of their willingness to recognize the good faith of one another in agreeing to live up to those standards. This aim was attained in the two articles just quoted, and the balance of the work of the conference related to detail, important in many respects, but necessarily incomplete. The step taken is a long advance in substance and principle over the practice of the past fifty years of enforcing uniform rules for preventing collisions at sea, and it begins an era in maritime affairs.

The agreement upon the two articles mentioned was not reached without patient effort, and involved, of course, concessions. The shaping of Article 61 was approached from two quite different points of view. By common consent, freedom on the open sea and the fact that vessels on the open sea remain under the authority of the flag state exclude as a rule the exercise of any state's authority over

foreign vessels at sea with certain exceptions, usually made in time of war. The extent to which this principle of the law of flag should be carried when it comes into contact with the law of the foreign port in which a vessel may find itself, was the subject of contention. The United States, from the time of Chief Justice Marshall, has strongly asserted the supremacy of the law of the port. The simplest statement of this principle is found in Wildenhus's case (120 U. S., 11, 12):—

"It is part of the law of civilized nations that when a merchant vessel of one country enters the ports of another for the purpose of trade, it subjects itself to the law of the place to which it goes, *unless by treaty or otherwise the two countries have come to some different understanding or agreement.*"

The British maritime policy in this respect is the same and years ago was carried so far as to evoke protest from the American Government. Continental nations, on the other hand, and especially Germany since 1870, have been disposed to emphasize the law of the flag (*droit du pavillon*) and to minimize the importance of the law of the port. The German contention at the London Conference was fortified by a presentation of the thorough system of inspection laws enforced on German merchant vessels, to which foreign vessels are not subject in German ports. The system of state workingmen's insurance against accidents and death, which obtains throughout Germany, is applied to her seamen on merchant vessels. Accordingly, a strong and direct pecuniary interest in the safety of German ships, their crews, passengers, and cargoes has been created among shipbuilders, shipowners, officers, and seamen quite apart from statutory requirements as to safety such as are imposed, for example, by the laws of the United States and the United Kingdom.

Article 61, it will be noted, strives to find common ground for both principles. It recognizes the principle of the law of the flag in so far as the article limits the inspection by the authorities of the foreign port to verification of the conditions set forth in the national certificate of safety. It recognizes the principle of the law of the port in so far as it enables the local authorities to assure themselves that the conditions making for safety on the vessel remain in fact such as they were certified to be by the national certificate. The law of the flag and the law of the port become identical in fact through the safety certificate. By consent of the conference, this subject was referred to the American and German delegations for solution, and Article 61, which probably received more critical study than any other one article of the Convention, was accepted without dissent as a just solution.

In supporting this article the American delegation was sustained by a long line of treaties and conventions entered into between the United States and nations with which they have commercial intercourse, the purpose of which is to secure to commerce the undoubted benefits which result from abstinence on the part of the local government from interference with the discipline and internal conditions of the foreign ship. To be sure, most of these treaties and conventions were entered into

at a time when the American flag was frequently seen on merchant vessels in foreign ports, but the principle maintained by the United States has not lost its value to international trade because the element of self-interest on our part has grown less. Even now its assertion, especially in ports of the republics to the south of us, is sometimes necessary. Furthermore, only eight years ago Congress passed a law (Act of March 17, 1906) providing that foreign passenger steamers in American ports shall be subject to no other inspection than is necessary to satisfy our inspection force that the condition of the vessel, her boilers and lifesaving equipments are as stated in her foreign certificate of inspection, that certificate being based on foreign requirements deemed equivalent to our own.

Articles 60 and 61 seem to me of especial interest to the Society of Naval Architects and Marine Engineers. The establishment of international standards of safety, coupled with the obligation upon each nation to guarantee that its own ships comply fully with the requirements of such standards, offers both positive and negative advantages to the successful prosecution of their work by a body of trained men such as compose the Society. The London Convention furnishes an impetus to high grade construction work in that it secures for such work international recognition. More than mere formality is intended by Article 64 of the Convention, by which the governments of the maritime powers agree to communicate to one another "all information which they possess affecting safety of life on those of their vessels which are subject to the rules of the Convention, provided always that such information is not of a confidential nature." This article was intended to mean that the best results of the best thought of ship and engine builders shall be exchanged between nations for critical study with a view to their incorporation, if practicable, into the rules fixing international standards of construction, and to facilitate this result the Convention in Article 74 provides "the governments may, through the diplomatic channel, introduce into this Convention, by common consent and at any time, improvements which may be judged useful or necessary."

Again, the due performance of the obligations imposed upon nations by the Convention will involve more intimate co-operation than in the past between the Department of Commerce, which is especially charged with the administration of laws relating to the merchant marine, and the Society of Naval Architects and Marine Engineers. Casual study of the twelve articles on Construction, comprising Chapter IV of the Convention, and the accompanying nine pages of regulations, will convince any reader that a small staff of well-trained naval architects must be created to work in or with the Department of Commerce, if the United States is to give effect to the Convention. Such a staff the British Board of Trade (which, of course, is a department of government, and not a board of trade as the words are used in this country) already possesses, and, through the operations of the Seeberufsgenossenschaft, Germany also obtains the best technical advice. How this co-operation is to be brought about and how this staff is to be organized are questions which may be reserved until the Convention has been ratified by the Senate of the United States. It is not, however, too early for the Society of Naval Architects and Marine Engineers to begin to think about the matter.

The negative advantages of the establishment of international standards will readily recur to anyone who has had occasion to observe the multitude of projects relating to the mercantile marine which spring up within and outside of Congress after any great event centering public interest on maritime affairs, such as the loss of the S. S. Titanic or the brief cessation of ocean transportation upon the several declarations of war in early August. We owe to the press and to electrical communication a heavy debt for prompt and wide dissemination of knowledge on any subject at any time, but the rapidity of communication in these days gives to immature or superficial projects, based often only on the desire for notoriety, a dangerous currency not possible in stage-coach days. Of course, these observations apply to the other countries as well as to our own, for the files of the British Board of Trade following the loss of the S. S. Titanic contain quite as many and quite as foolish suggestions as those to be found in the department records at Washington. The steadying effect of international standards on subjects relating to safety of life at sea is insurance against thoughtless or harmful suggestions of legislation or regulation and attempts to pervert public sentiment to the attainment of selfish ends.

The limits of this paper and of my technical knowledge forbid a general review of the provisions of the Convention. Usually they are stated so clearly in the seventy pages of the document that review is unnecessary. It is worth noting, however, that instead of the tonnage rule or the passanger rule for lifeboats the Convention adopts the safe and sane rule that, as the length of the vessel is the principal factor in determining the number of davits which may be erected, and as the number of davits determines the number of lifeboats which may be launched promptly, the lifeboat capacity shall be fixed in relation to the vessel's length. Of course, lifeboats in excess of the total number of persons on board are not required in any event. The Convention rules, if applied to the 5,647 transatlantic voyages of passenger ships between the United States and Europe during 1912 and 1913, would have provided lifeboats for all on board except in 392 cases, and in many of these the operation of other provisions of the Convention would have brought passengers lists within the lifeboat rules.

The provisions in Articles 33 and 34 for a continuous wireless watch on all vessels equipped with radio apparatus, together with the requirement in Article 37 binding the master of every vessel to proceed to the assistance of a vessel in distress, constitute the broadest declaration ever made by maritime nations in statutory form of the principle of the mutual obligation of those at sea to aid one another when in distress. In the case of cargo boats or small passenger vessels doing little commercial wireless business one operator evidently would suffice to send out distress calls in event of casualty imperiling those on board. The second operator or watcher in the case of such vessels, however, is prescribed in the interest of safety of those on board other vessels and is thus, in effect, a tax upon the owners of such vessels to insure the general safety of ocean navigation.

The Convention applies to mechanically propelled ocean vessels (steam, motor and internal-combustion engines) which carry more than twelve passengers, in for-

eign trade between the nations which ratify the Convention. Each nation, of course, reserves its coasting trade for its own legislation. Each nation is at liberty to exempt from the rules of the Convention vessels which go less than two hundred miles from the nearest coast. This exemption was drawn principally to cover the trade across the channel between Great Britain and the Continent, which from Brest to the river Elbe has been described as "home trade" for many years in British laws. It would, of course, cover trade on the Baltic and on the Mediterranean if the nations with coasts on those seas deem it wise to exempt those trades. Trade on our Great Lakes is, of course, reserved from the operations of the Convention.

The American delegation at the outset favored the preparation of a convention which should also apply to freight steamers. It soon became evident, however, that to draft the different rules required for freight steamers would unduly prolong the conference, and would also so overload the conference that much less satisfactory conclusions as to passenger steamers could be reached. This difficulty was particularly serious in the matter of hull construction, where the problems connected with cargo are somewhat different from those connected with passenger steamers.

The Convention was to have been ratified not later than December 31, 1914, and was to have taken effect on July 1, 1915. At the outbreak of the European war, good progress had been made toward ratification. The Convention was ratified by the German Reichstag in May, and its promulgation awaited only agreement upon the schedule of exempted voyages. In Great Britain the bill to carry out the Convention was laid before Parliament in May and according to programme was enacted August 10, 1914, shortly after the passage of the Home Rule Bill for Ireland. The bill to give the Convention effect in France was laid before the Chamber of Deputies in February and, while its consideration was somewhat delayed by the general elections in France, its passage was expected in the autumn. The Spanish Government also was confident that the treaty would be ratified and the necessary legislation enacted as soon as the Cortes meets in the autumn. The bill to give effect to the treaty was laid before the Parliament of The Netherlands in the early summer and its enactment in September was expected. The ratification of the Convention by Belgium and Italy, and the passage of bills to give effect to its provisions introduced in the spring, were expected in November. Austria, late in the spring, had expressed its readiness to ratify the Convention at any time, but its action was dependent somewhat upon that of Hungary, where it had not yet been decided whether approval by the Hungarian Parliament was necessary in advance of the royal signature. As the Danish Parliament does not meet until 1915, the Danish Government was granted a special delay by the Protocol of the Convention itself until April 1, 1915. Sweden, too, could not act until the Rigsdag assembles in 1915, as the money appropriation for the ice patrol must have legislative approval. I am not advised as to the progress of the Convention in Norway and Russia. The Senate Committee on Foreign Relations of the United States Senate was prepared to report the Convention for the consideration of the Senate on June 10, but as the form of ratification agreed to presented some difficulties it was reserved for

further consideration. The situation, of course, has been entirely changed by the events of August. Undoubtedly it will be necessary to extend by common consent beyond December 31, 1914, the period for the exchange of ratifications, and beyond July 1, 1915, the date when the Convention shall go into effect. The duty of the United States to give cordial approval to the International Convention and the opportunity as the one great neutral nation promptly to do so have joined.

DISCUSSION.

THE CHAIRMAN:—Does any member wish to discuss this paper or make any comments upon it?

PROF. HERBERT C. SADLER, *Member of Council:*—I make a suggestion that the second paper be read at this time, as the discussion will probably cover both papers.

THE CHAIRMAN:—That suggestion will be acted upon if there is no objection. We will therefore have paper No. 2, entitled "Safety of Life at Sea. Application of Subdivision Rules Adopted at International Conference," by Mr. James Donald, Member.

Mr. Donald presented his paper in abstract. In reading the abstract, Mr. Donald said:—

"I would like to read an extract from page 22 of the main paper, as follows: 'It is not intended in this paper to make any criticism of the results of the labors of the Convention,' because the Convention has arrived at a great many good rules for advancing the subject considerably. I say further in my paper, 'An endeavor is made to place before you the types of United States vessels that are or should be effected by the Convention.' In fact, I think that the Convention with regard to the question of Subdivision might have gone even further as regards the passenger steamers. Of course, the Convention has made a beginning, and we hope what they have done will be carried out and even increased still further."

SAFETY OF LIFE AT SEA. APPLICATION OF SUBDIVISION RULES ADOPTED AT INTERNATIONAL CONFERENCE.

By James Donald, Esq., Member.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

On the invitation of the Secretary of the Society of Naval Architects and Marine Engineers, the preparation of this paper has been undertaken, and an effort has been made to handle it from the viewpoint of the man who must apply the rules to actual designs.

As the members of this Society already know, a preliminary committee was appointed by the Secretary of Commerce in May, 1913, for the purpose of obtaining information relative to structural subdivision of vessels, this information being for the use of the Department of Commerce and the representatives who would represent the United States at a later date at the International Conference on Safety at Sea in London.

In June, 1913, a circular letter was sent by the Secretary of Commerce to all those interested in matters affecting American shipping, and in September, 1913, a report was made to the Secretary of Commerce by the preliminary committee embodying the information received from these interested parties.

Eleven commissioners were sent to London to represent the President of the United States of America at the International Conference on Safety of Life at Sea which was held from November 12, 1913, till January 20, 1914.

In April, 1914, there was published by the Government Printing Office, Senate Document No. 463,* Sixty-third Congress, second session. It is entitled:—"International Conference on Safety of Life at Sea," and contains Messages from the President of the United States transmitting an authenticated copy of the International Convention relating to Safety of Life at Sea, the detailed regulations thereunder, a final protocol, and the *"voeux"* expressed by the conference, all signed at London, January 20, 1914; and a Report from the United States Commissioners to the International Conference on Safety of Life at Sea, giving a summary of the subjects considered and the conclusions arrived at as embodied in the Convention, together with the Report of Andrew Furuseth submitted to the President after his resignation as Commissioner from the United States, and a Memorial of the International Seamen's Union of America.

Hereafter in this paper, wherever the aforementioned Senate Document is referred to, it will simply be called Senate Document No. 463.

In order to apply the rules adopted by the International Convention it is necessary to know what vessels are affected by the Convention.

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*Published as an appendix to this Volume.

VESSELS AFFECTED BY THE CONVENTION.

Trade Routes.—Referring to Senate Document No. 463, Convention Article 2 specifies that—

"Except where otherwise provided by this Convention, the merchant vessels of any of the states of the High Contracting Parties which are mechanically propelled, which carry more than twelve passengers and which proceed from a port of one of the said states to a port situated outside that state, or conversely, are subject to the provisions of this Convention. Ports situated in the colonies, possessions or protectorates of the High Contracting Parties are considered to be ports outside the states of the High Contracting Parties."

Convention Article 3 requires that—

"There are excepted from this Convention, save in the cases where the Convention otherwise provides, vessels making voyages specified in a schedule to be communicated by each High Contracting Party to the British Government at the time of ratifying the Convention."

"No schedule may include voyages in the course of which the vessels go more than 200 sea miles from the nearest coast."

Referring to Senate Document No. 463, page 78, line 8, the Chairman of the United States Commissioners reports to the President of the United States that—

"In the case of the United States such over-sea possessions include the Philippines, Alaska, Hawaii, Porto Rico and the Canal Zone. Alaska, Hawaii and Porto Rico are included under the coasting laws of the United States, and the American delegation was instructed not to commit the United States to coasting regulations."

Vessels trading between a port on the east coast of the United States and a port on the west coast of the United States, via the Panama Canal or conversely, will be in the coasting trade, unless they stop at a port during the voyage. If, for example, one of these vessels should have any transactions, passenger or freight, with the cities of Colon or Panama, the vessel would have to be registered for the foreign trade and would be subject to the Convention requirements.

Referring to Senate Document, No. 463, page 78, line 35, the "immense trade on the Great Lakes is not brought under the Convention."

Types of Vessels.—Referring to Senate Document No. 463, page 77, line 1—

"The Convention applies to mechanically propelled (steam, motor, and internal combustion) merchant vessels which carry more than twelve passengers. * * * The American delegation at the outset favored the preparation of a convention which should also apply to freight steamers. It soon became evident, however, that to draft the different rules required for freight steamers would prolong the conference much beyond the time this delegation was prepared to remain, and would also

so overload the conference that much less satisfactory conclusions as to passenger steamers could be reached. This difficulty was particularly serious in the matter of hull construction, where the problems connected with cargo are somewhat different from those connected with passenger steamers. Furthermore, an international conference is to be held at London later this year to consider uniform load lines and deck loads, and Congress has provided for American representation at this conference which will consider more particularly cargo vessel problems."

The vessels affected by the Convention are divided into "new vessels" and "existing vessels."

According to Convention Article 16—

" 'New' vessels are those the keel of which is laid after July 1, 1915."

"Other vessels are considered as 'existing' vessels. Existing arrangements on each of these vessels shall be considered by the Administration of the state to which the vessel belongs, with a view to improvements providing increased safety where practicable and reasonable."

Summary.—Therefore the vessels to which the convention articles and regulation articles apply are United States existing or new passenger vessels which are or will be engaged in trades between the United States and the ports of any of the High Contracting Parties of the International Convention on Safety of Life at Sea, between the United States and the Philippines and between the United States and the Canal Zone.

The existing vessels actually affected will be a few steamers trading between the west coast of the United States and the Philippines, a few in the transatlantic trade and the foreign steamers that may be registered under the new act approved on August 18, 1914. These vessels will have their existing arrangements considered by the Administration with a view to make them conform to the Convention requirements "providing increased safety where practicable and reasonable."

The Convention requirements will be applied to all "new" passenger vessels which will be built for the foreign trade. Unfortunately there are none building. The United States is therefore in the position of having safety rules ready at the beginning of the upbuilding of her merchant service in the foreign trade.

APPLICATION OF CONVENTION RULES.

We now come to the point in this paper where the effort is to be made to apply the Convention rules to actual designs.

As the few existing United States vessels in the foreign trade are all of different design and fall short of the Convention requirements it would not be possible within the limits of such a paper to deal with each case, even if the information were available. It rests with the Administration to consider each case so as to ensure increased safety where practicable and reasonable.

As regards "new" United States vessels in the foreign trade it may be stated in general that the Convention requires that the spacing of watertight bulkheads in "mixed cargo and passenger" vessels of 571 feet in length and above, and in "passenger" vessels of 489 feet in length and above, will be such that any two adjoining main transverse compartments may be flooded without resultant foundering of the vessel. There are special requirements in the larger vessels for closer spacing of watertight bulkheads at the forward end. Vessels of less length than the above will be able to float with any one compartment flooded without resultant foundering.

It therefore does not seem to be of much interest for us to study examples of the application of the Convention rules to actual designs as these rules only apply to United States vessels in the foreign trade. In a general way the preceding paragraph describes the basis on which the subdivision of these vessels would be made.

It seems, however, an opportune time to consider the conditions of vessels in the coastwise trade with special regard to increased safety at sea.

As the Convention applies only to United States vessels engaged in the foreign trade, and as many routes in the coastwise trade are as dangerous as those in the oversea trade owing to rough weather, fogs and possible collisions, it would appear consistent to legislate for increased safety in vessels engaged in the coastwise trade.

The Preliminary Committee in the circular issued by the Secretary of Commerce in June, 1913, evidently had this in mind when it said, page 1, line 23:—

"It will be noted, however, that some of the questions relate to vessels whose service is such as to place them beyond the scope of the proposed international conference. While the authority for suitable structural subdivision of these vessels to insure safety in operation is already contained in general terms in the provisions of statute law, the Department desires to embrace this opportunity to obtain the opinions of those highly qualified to render assistance in such matters, with a view to improving the present conditions."

This is also borne out by reference to the questions relating to Classes I*b*, II*b*, and III*b*.

In Convention Article 3—

"There are excepted from this Convention, save in the cases where the Convention otherwise provides, vessels making voyages specified in a schedule to be communicated by each High Contracting Party * * *."

"No schedule may include voyages in the course of which the vessels go more than 200 sea miles from the nearest coast."

This may mean that vessels in certain coastwise trade routes may be affected by the Convention.

In Convention Article 66—

"The High Contracting Parties which intend the Convention to apply to the whole of their colonies, possessions and protectorates, or to one or to some of these countries, shall declare this intention either at the time of signing these presents or subsequently."

This also seems to indicate that vessels in certain coastwise trade routes may be affected by the Convention.

We may therefore proceed to apply the Convention requirements to some types of vessels operated in the coastwise trade. In case the members have not a copy of Senate Document No. 463 at hand it has been considered advisable to include herewith a copy of the more important Convention Rules relating to the Subdivision of Vessels.

CONSTRUCTION.

ARTICLE V.—*Definitions.*

The meaning of the principal technical and other expressions contained both in the Convention and in these regulations, under the heading of Construction, is as follows:—

1. The load waterline is the waterline used in determining the subdivision of the vessel.

2. The length of the vessel is the extreme length at the load waterline.

3. The breadth of the vessel is the extreme width from outside of frame to outside of frame at or below the load waterline.

4. The bulkhead deck is the uppermost continuous deck to which all transverse watertight bulkheads are carried.

5. The margin line is a line drawn parallel to the bulkhead deck at side line, and 3 inches below the upper surface of that deck at side.

6. The draught is the vertical distance from the top of keel amidships to the load waterline.

7. The freeboard is the vertical distance from the load waterline to the margin line amidships.

8. The depth of the vessel is the sum of the draught and freeboard as above defined.

9. The sheer of the bulkhead deck at any point is the vertical distance between the beam at side line at that point and a line drawn parallel to the load waterline at the height of the beam at side line amidships.

10. If block coefficient of fineness of displacement to load waterline is used, this coefficient shall be determined as follows:—

$$\frac{\textit{Volume of displacement to molded lines}}{\text{Length} \times \text{Breadth} \times \text{Draught}}$$

11. The permeability of a space is the percentage of that space which can be occupied by water.

The volume of a compartment which extends above the margin line shall be measured only to the height of that line. Volumes shall be understood as volumes to molded lines.

12. The machinery space is to be taken as extending in length between the extreme main transverse watertight bulkheads bounding the spaces devoted to the main and auxiliary propelling machinery, including boilers when installed.

Article VI.—*Floodable Length.*

The floodable length at any point of the length of a vessel shall be determined taking into consideration form, draught, and other limiting characteristics of the vessel in question.

This floodable length for a given point in a vessel with a continuous bulkhead deck is the maximum percentage of the length of the vessel (having its center at the point in question) which can be flooded under the definite assumptions hereafter set forth in Article VII without the vessel being submerged beyond the margin line.

In the case of vessels not having a continuous bulkhead deck, the floodable length must be such as to secure to the vessel in question, for each portion of its length, and for all conditions of trim after damage, a measure of safety at least equal in effectiveness to that laid down for the vessel with continuous bulkhead deck.

Article VII.—*Permeability.*

The definite assumptions referred to in Article VI relate to the permeabilities of the spaces in question below the margin line.

In determining the floodable length a uniform average permeability shall be used throughout the whole length of each of the three following portions of the vessel:—

1. The machinery space.
2. The portion forward of the machinery space.
3. The portion abaft the machinery space.

For steam vessels the permeability of the machinery space, including the double bottom in wake thereof, shall be taken as 80 per cent. For vessels fitted with internal-combustion engines the corresponding permeability shall be taken as 85 per cent, unless it is proved by actual calculation that a lower figure may be adopted, provided that in no case shall that figure be less than 80 per cent.

The permeabilities for spaces forward and aft of the machinery space shall be as follows:—

(*a*) Sixty per cent in cargo spaces, bunkers (permanent or reserve), storerooms, baggage and mail rooms, chain lockers, watertight shaft or pipe tunnels, and fresh-water tanks above the double bottom.

It must be proved that the spaces just enumerated are practicable for the purpose intended and that they are in fact to be so used. The same permeability shall not be assigned to any other space without the approval of the Administration.

(*b*) Ninety-five per cent in passenger and crew spaces, peaks, trimming tanks exclusively so used, double bottoms, and all other spaces not specifically appropriated to one of the purposes indicated in the foregoing Section (*a*).

If in a 'tween-deck space inclosed by complete transverse permanent steel bulkheads any portion thereof is appropriated to passengers, the whole of that space shall be regarded as passenger space; and, similarly, 'tween-deck spaces appropriated for the carriage of either passengers or cargo shall be regarded as passenger spaces.

Where the space before or abaft the machinery space below the margin line consist partly of spaces mentioned in Section (*a*) and partly of spaces mentioned in Section (*b*), the average percentage of permeability shall be determined separately for each end by the formula $95 - 35r$, where r is the ratio between the volume of the spaces mentioned in Section (*a*) and the total volume of the space in the portion of the ship under consideration.

Article VIII.—*Permissible Length of Compartments.*

1. The maximum permissible length of one compartment having its center at any point in the vessel's length is obtained from the floodable length (Article VI) by multiplying that length by an appropriate factor, called the factor of subdivision.

2. This factor of subdivision depends on the length of the vessel, and, for a given length, varies according to the nature of the service for which the vessel is intended. This factor decreases in a regular and continuous manner—

(*a*) As the length of vessel increases; and

(*b*) As, for a given length, the vessel departs from the type of vessel engaged in a mixed cargo and passenger service, and approaches to the type of vessel primarily engaged in the transportation of passengers.

3. For each of the two types of vessels referred to in the previous paragraph 2, (*b*), the variation of the factor of subdivision may be expressed by a curve, of which the co-ordinates represent the length of the vessel and the value of the factor. The following table gives certain points on two curves the higher of which corresponds to the minimum requirements for the "mixed" type, and the lower to the minimum requirements for the "passenger" type.

A.	B.	C.
	Feet.	Feet.
1.00	295	259
0.90	374	285
0.84	404	305
0.65	489	380
0.50	571	489
0.39	699	685
0.34	899	899

Column A gives the maximum permissible values of the factor of subdivision for the length of vessels given in columns B and C.

Column B is applicable to vessels engaged in a mixed cargo and passenger service.

Column C is applicable to vessels primarily engaged in the transportation of passengers.

4. For a given length, the value of the factor of subdivision appropriate to a vessel between the two extreme limits will be between the values of the factors determined by the two curves before mentioned, and will be automatically fixed by a "criterion of service" which is to form the subject of further study.

Article IX.

1. When the factor of subdivision is equal to or less than .5, it may be doubled in order to give at any point of the vessel's length the total length of two adjacent compartments; but, in that case, the length of the shorter compartment of any pair shall not be less than one-quarter of the total length so obtained. If one of the two adjacent compartments is situated inside the machinery space and the second is situated outside the machinery space, and the average permeability of the portion of the ship in which the second is situated differs from 80 per cent, the length of the pair of compartments shall be adjusted to the proper value by applying a suitable correction.

2. In no case whatever shall the length of any watertight compartment exceed 92 feet.

3. When the factor of subdivision applicable to any vessel is less than .84, but more than .5, the combined length of the two foremost compartments shall not exceed the floodable length at the extreme forward end, provided also that the length of the second compartment is not greater than that permissible by Article VIII above, and not less than 10 feet.

4. When the length of the vessel is more than 699 feet, but less than 823 feet, the floodable length at the forward end of the vessel shall be at least 20 per cent

of the vessel's length; and the vessel, forward of a bulkhead placed either at the distance of the actual floodable length abaft the stem or not nearer to the stem than 20 per cent of the vessel's length, shall be divided into at least three compartments.

5. When the length of the vessel is equal to or greater than 823 feet the same method shall be adopted, but the floodable length shall be at least 28 per cent and the number of compartments at least four.

6. A bulkhead may be recessed transversely, provided the sides of the recess are at a sufficient distance from the sides of the vessel.

Vertical steps are inadmissible in the main transverse watertight bulkheads of vessels to which the subdivision rules of Article VIII apply where the factor of subdivision is greater than .5, unless such arrangements are made by additional subdivision as shall maintain the same measure of safety as that secured by bulkheads without steps. The total length of the steps in any bulkhead shall not exceed 2 per cent of the vessel's length, plus 10 feet.

7. The existence of recesses or steps in a bulkhead shall in no case affect the permissible volumes of the compartments adjacent to such bulkhead, as determined by this and the preceding article.

Article X.

If the degree of safety of a vessel is greater than that prescribed by Articles VIII and IX above, and if the owner requests that this fact be recorded on the Safety Certificate, in accordance with Article 17 (paragraph 4) of the Convention, this request shall be accompanied with all the data necessary to justify this claim.

In such case, the record shall state the fact that the subdivision is equal or superior to that provided for a vessel of equal length in column C of the table in Article VIII, with an additional statement giving the length of the vessel in column C whose factor of subdivision according to the rules would be exactly equal to that employed in determining the subdivision of the vessel in question.

Values of length and factors for lengths not specifically stated in columns C and A, respectively, of the table in Article VIII shall be obtained by interpolation.

Article XI.—*Peak and Machinery Space Bulkheads.*

Vessels shall be fitted with a forepeak bulkhead to extend to the bulkhead deck, and to the weather deck in vessels having continuous superstructures. This bulkhead shall be placed at a distance of not less than 5 per cent of the vessel's length from the stem at the load waterline.

An afterpeak bulkhead and bulkheads dividing the machinery space from the cargo and the passenger spaces shall also be fitted and carried up to the bulkhead deck. The afterpeak bulkhead may, however, be stopped below the bulkhead deck, provided that it shall at least be carried to the first deck above the load waterline,

and that such deck forms a watertight flat from the afterpeak bulkhead to the stern, and also provided that the degree of safety of the vessel as regards subdivision is not thereby diminished.

Article XXI.—*Double Bottoms.*

1. In vessels 200 feet and under 249 feet in length, a double bottom shall be fitted at least from the machinery space to the forepeak bulkhead, or as near thereto as practicable.

2. In vessels 249 feet and under 300 feet in length, a double bottom shall be fitted at least outside of the machinery space and shall extend to the fore and afterpeak bulkheads respectively, or as near thereto as practicable.

3. In vessels 300 feet and over in length, a double bottom shall be fitted amidships and shall extend to the fore and afterpeak bulkheads respectively, or as near thereto as practicable.

4. In vessels over 300 feet in length, the inner bottom shall be continued out to the vessel's side in such manner as to protect the bilges.

5. In vessels over 699 feet in length, the double bottom, for at least half the vessel's length amidships and forward to the forepeak bulkhead, shall extend up the vessel's sides to a height above the top of the keel not less than 10 per cent of the vessel's molded breadth.

6. Wells constructed in the double bottom in connection with the drainage arrangements shall not extend downwards from the inner bottom more than half the depth of the double bottom at that point. A well extending to the outer skin is, however, permitted at the after end of the shaft tunnels of screw vessels.

REMARKS ON CONSTRUCTION.

Referring to the above Convention Rules it may be interesting to know how they would affect coastwise vessels if these rules were applied to such vessels. Your attention is therefore called to the rules mentioned herewith and to the remarks appended thereto.

Load Line.—Referring to Regulation V, Paragraph 1:—

"The load waterline is the waterline used in determining the subdivision of the vessel."

As there is no statutory load line or freeboard in the Navigation Laws of the United States and as there is no reference in Senate Document No. 463, in the Convention Articles, the Regulation Articles, nor in the Report of the Commissioners of the United States of America to the President of the United States as regards any statutory load line or freeboard it seems absolutely necessary that the United States should adopt some load line regulation before enforcing the new subdivision of vessels.

It may be intended to pass load line legislation for United States vessels as arrangements are made for an International Load Line Conference (see Senate Document No. 463, page 68, Recommendation 12):—

"The International Load Line Conference, which the British Government proposes to convene as soon as the necessary preliminary work is completed, should deal if possible with deck cargoes of timber and wood,"

and the Report of the Commissioners of the United States of America to the President of the United States, Chapter II, which says:—

"Furthermore, an International Conference is to be held at London later this year to consider uniform load lines and deck loads, and Congress has provided for American representation at this conference which will consider more particularly cargo vessel problems."

Of course it would be possible to submit the location of the load line with the application for the safety certificate required in Regulation LII and have this load line marked on the vessel.

Floodable Length.—Referring to Regulation Article VI, Floodable Length:—

"The floodable length at any point of the length of a vessel shall be determined by taking into consideration form, draught and other limiting characteristics of the vessel in question.

"This floodable length for a given point in a vessel * * * is the maximum percentage of the length of the vessel (having its center at the point in question) which can be flooded under the definite assumptions hereafter set forth in Article VII without the vessel being submerged beyond the margin line."

These two paragraphs call for a great deal of calculation, and if they are to be followed should have a set of curves added to them so that a department could use them. It means a series of calculations and curves for each type of steamer, varied to suit the block coefficient, the ratio of draught to depth of vessel, to location of machinery and to sheer of bulkhead deck. It would be possible to construct a series of curves of floodable length for a few standard types and calculate separately for unusual types as occasion required.

Permissible Length of Compartments.—On Plate 1 will be found two curves conforming to the table in Regulation Article VIII. As mentioned in this article, in Section 4, these curves will be fixed by a "criterion of service" which is to form the subject of further study.

Double Bottoms.—It will be noticed in Regulation Article XXI that all passenger vessels above 200 feet in length will have a double bottom. If this is applied to the coastwise trade, it will affect a very large number of vessels.

Openings, Doors, etc., in Watertight Bulkheads.—There are regulations relating to fireproof bulkheads, exits from watertight compartments, testing of bulkheads, openings in bulkheads and in vessel's sides, etc. It is not considered neces-

sary to refer to these as they do not affect the general design of the vessel, except as mentioned later as regards doors in bulkheads and openings in vessel's side.

APPLICATION OF CONVENTION REQUIREMENTS TO COASTWISE VESSELS.

In order to show how the Convention requirements would affect a vessel in the coastwise trade, a typical passenger and freight steamer as used on the east coast of the United States is herewith taken.

Plate 2, profile D, shows the vessel as built.

On Plate 3, profile E, the main deck is taken as the bulkhead deck and the floodable lengths have been shown, spacing them off firstly from the machinery space and then toward the ends of the vessel. A curve of floodable lengths is also given.

Plate 4 gives diagrams showing the vessel floating at the margin line. The watertight bulkheads are located as in profile E and form the boundaries of the floodable lengths.

By referring to Plate 1, curves of factors of subdivision, and allowing that the vessel under consideration is half-way between types B and C, for the vessel's length which is 385 feet we obtain a factor of subdivision of .76. Multiplying the floodable lengths shown on profile E by this factor of .76 we obtain the spacing of the watertight bulkheads as shown on profile F.

On Plate 5, profile G, the watertight bulkheads have been spaced as required by Department of Commerce, Steamboat-Inspection Service Rule III, Section 24, Edition January 13, 1914.

Comparing profile D, as built with profile F, as required by the Convention, this vessel, if affected by the Convention, will require two more bulkheads fitted forward unless the machinery space is placed further forward or other arrangements made. This vessel will also require two watertight bulkheads in the after hold and be fitted with a double bottom all fore and aft, whereas at present this vessel has only a double bottom under the engine room. If this vessel were built to conform to the Convention requirements, it will be seen from this example how some of the coastwise passenger and freight steamers would require more bulkheads in the hold and 'tween decks; the vessel would require more depth so as to allow of a double bottom being fitted and to allow of the arrangement of the doors in watertight bulkheads and through the vessel's side to be above the load waterline.

It should be noted that this vessel as arranged on profile F will founder if she has any two adjoining compartments flooded. The same remark applies to profile G, where the watertight bulkheads are arranged according to the Steamboat-Inspection Rules.

On Plate 5, profile H, the bulkhead deck has been taken at the hurricane deck and, with the spacing of watertight bulkheads shown, the vessel will float with any two adjoining compartments flooded, assuming that the vessel has sufficient stability in this condition.

Particular attention should be made to the following requirements:—

In Senate Document No. 463, Regulation Article XV, Section 2—

"No doors, sluice valves, manholes or access openings are permitted—(*b*) in watertight transverse bulkheads dividing a cargo space from an adjoining cargo space or from a reserve bunker, except as provided in paragraph 6 of this article.

"6. Hinged watertight doors of specially heavy design may be fitted above the load waterline in bulkheads between cargo 'tween-deck spaces. They shall be closed before the voyage commences, and kept closed while at sea by efficient closing gear."

In Regulation Article XVI, Openings in Vessel's Side—

"9. In no case shall gangway, cargo, and coaling ports be fitted below the load waterline."

To further show the effect of the Convention requirements a typical passenger and freight steamer as used on the west coast of the United States is herewith taken.

Plate 6, profile J, shows the vessel as built.

On Plate 7, profile L, the floodable lengths have been shown, and a curve of floodable lengths given.

Referring to Plate 1, Curves of Factors of Subdivision, this vessel is taken as conforming to curve B, and for her length of 420 feet we obtain a factor of subdivision of .8. Multiplying the floodable lengths shown on profile L by .8 we obtain the spacing of the watertight bulkheads shown on profile M.

As this disposition of watertight bulkheads does not suit the length of the machinery space a rearrangement is necessary, which is shown in profile N. By arranging the engines and boilers in two separate watertight compartments we obtain a better arrangement of bulkheads in the cargo holds.

On Plate 6, profile K, the watertight bulkheads have been spaced as required by the Department of Commerce, Steamboat-Inspection Service Rule III, Section 24, Edition January 13, 1914.

Comparing profile J vessel as built with profile N, as required by the Convention, this vessel, if affected by the Convention, will require one more watertight bulkhead.

It should again be noted that this vessel as arranged on profile N will founder if she has any two adjoining compartments flooded. The same remark applies to profile K, where the watertight bulkheads are arranged according to the Steamboat-Inspection Rules.

CONCLUSION.

Referring to Senate Document No. 463, the International Conference recognized the great amount of work to be done in studying the Construction of vessels so as to insure increased safety, and on pages 84, 85 and 86 a list of subjects is given which shows the extent of the work of the Committee on Construction.

It is not intended in this paper to make any criticism of the results of the labors of the Convention. An endeavor is made to place before you the types of United States vessels that are or should be affected by the Convention.

In order to improve the conditions of safety of life in United States vessels it is suggested that the question of increased safety in coastwise vessels should be considered by the Department of Commerce on the basis of the Convention, or even on a basis insuring greater safety than contained therein.

In order to assist in the application of the Convention requirements, the following suggestions are made:—

1. That statutory load line or free-board legislation should be enacted.

2. That curves of floodable lengths should be constructed and issued by the Department of Commerce for standard types of United States vessels.

3. That a detailed definition of the "criterion of service" in Regulation Article VIII be given after this has formed the subject of further study as suggested by the Convention.

DISCUSSION.

THE CHAIRMAN:—These two papers are now open for general discussion.

PROF. HERBERT C. SADLER, *Member of Council:*—I think as naval architects and marine engineers we all welcome the results of the work of the International Conference. There are one or two sentences in the first paper to which I think particular attention should be called. As individuals, some of us have been called in in consultation in connection with legislation, but as a Society, as a whole, we perhaps have not received the recognition that we should have had in the past. Beginning on the bottom of page 5 of the first paper, Mr. Chamberlain makes a suggestion which looks to me like a step in the right direction. He says:—

"Casual study of the twelve articles on Construction, comprising Chapter IV of the Convention, and the accompanying nine pages of regulations, will convince any reader that a small staff of well-trained naval architects must be created to work in or with the Department of Commerce, if the United States is to give effect to the Convention."

I think that is a very good suggestion, and a very helpful one. I think that the profession should be consulted in connection with legislation of this character. There is another sentence, on page 6, which I think is particularly forceful:—

"The steadying effect of international standards on subjects relating to safety of life at sea is insurance against thoughtless or harmful suggestions of legislation or regulation and attempts to pervert public sentiment to the attainment of selfish ends."

I wish to call attention particularly to these two sentences. With the best intentions possible, sometimes our legislators are apt to draw wrong conclusions, and a demonstration upon the calm waters of the Potomac River does not necessarily reproduce the conditions of storm on the Atlantic in midwinter.

There is another sentence in the second paper which I would like to correct. On page 11, top of the page, it says:—

"Furthermore, an International Conference is to be held at London later this year to consider uniform load lines and deck loads, and Congress has provided for American representation at this Conference which will consider more particularly cargo vessel problems."

The United States originally provided for a Commission to attend the second, and to my mind, perhaps the more important, conference. The members of the Society may not be aware that the present Senate refused to appropriate anything towards the expenses for the delegates to this Convention, and this action was taken *before* the war broke out. So, as it stands at present, the United States will not be represented at the conference on load lines unless some change is made in the legislation on the subject.

Mr. J. Howland Gardner, *Member:*—I have read, with a great deal of interest, Mr. James Donald's paper on the "Application of Subdivision Rules Adopted at the International Conference," and I believe that he should be congratulated on this very interesting contribution on this most important subject.

There are one or two questions I would like to ask for my own information. The first is: Did he use the factors of permeability, as outlined by the London Conference, in making the calculations? I presume, of course, that this was done. I would also like to ask if he cares to express an opinion as to the practical correctness of these factors. It is interesting to note to what extent the question of bulkhead divisions has been considered by the United States Government, although this question has repeatedly been brought to its attention. Our chairman, Mr. Stevenson Taylor, could tell you of repeated efforts on his part to persuade the United States Government to adopt proper rules and regulations for proper bulkhead spacing and construction. In the new rules just published, the subject of bulkheads occupies less than one page; rules regarding life preservers occupy two pages; fire apparatus, four and one-half pages; boats and rafts, thirteen and two-thirds pages. The rules and regulations are apparently formulated to provide for possible escape in case of disaster rather than the idea of preventing the necessity of escape by proper hull construction. The findings of the London Conference do not apply, nor were they ever intended to apply, to American coastwise trade. The following was therefore suggested at a recent hearing in Washington:—

"A great deal has been said and many pages written on 'safety of life at sea,' and yet the real safety of the vessel with proper arrangement of bulkheads has received only a passing comment. The rules govern the spacing of bulkheads, but are silent in regard to depth except that bulkheads must extend above the deep load line. It is perfectly possible to build a vessel that will in every way comply with these rules and regulations, but she will not float if one principal compartment is open to the sea. The unsinkable ship has yet to be produced, but vessels should be so constructed that they will withstand ordinary collisions. It is not only necessary that they float when one or more of the principal compartments are

flooded, but it is quite as important to have the hulls so designed that the vessel will be stable under these conditions. The present government requirements for lifeboats and boat-handling gear is a serious problem on many ships. Little attention has been paid by the Government to this important question of stability in damaged condition. Vessels built in accordance with the present rules and regulations will sink in from ten to fifteen minutes if they meet with even a slight damage. It is only necessary to have a leak in one compartment that exceeds the capacity of the wrecking pumps. The time of foundering of a vessel depends only on the time required to fill. One might well ask the question why we have so few marine disasters. It is because the men who own and operate vessels are not satisfied to build in accordance with the government regulations, but they insist on a better arrangement of bulkheads. The saying that one should not criticize unless he is prepared to furnish blueprints for something better is especially applicable in this case, and I would like to take this opportunity to say that this problem has not yet been satisfactorily solved. The various services in which vessels are engaged make it necessary to adopt different types of construction; for example, in sound service, no bulkheads are required by law, yet there is no class of vessels where the problem has been more successfully solved than in this particular line of shipping, and there are to-day no vessels under the American flag better equipped along this line. The very nature of the service gives the designer a chance at bulkhead arrangements that might not be practical in some other line of trade where the problem is more complicated.

"I would, therefore, suggest that a committee be formed to study this very important subject and its application to the American trade. This committee should be composed of representatives of the United States Steamboat Inspection Service, designers, builders, and owners. They should prepare rules and regulations governing the construction, location of bulkheads, the height of bulkheads and their relation to the maximum load line. They should further consider the necessity for double-bottom construction and the extent to which this should be carried on American vessels. After they have completed this most important problem they should take up the complete revision of the present rules and regulations of the Steamboat Inspection Service.

"I do not want the Board of Supervising Inspectors to think that in making these suggestions I am casting any reflection upon the Board. As a matter of fact, designers and owners cannot now agree on what should be required or is necessary in all cases. It is, therefore, not at all surprising that the present government rules and regulations are inadequate for the present conditions. The art of shipbuilding and designing has made very rapid strides in the last few years, and in order to keep up with this progress, new rules and regulations have been added from time to time; these should be collected and brought up to date. The committee, representing, as it would, all sides of the subject, with the assistance gained by properly conducted hearings should be in a position to produce results that would be of great value to the entire country."

I wish to take this opportunity to solicit the hearty co-operation of all members of the Society of Naval Architects and Marine Engineers, to the end that we may impress upon the Government the necessity of a committee to revise the present rules and regulations, and if I am entirely in order, and I know that the chairman will correct me if I am not, I will make a motion that a committee be appointed by the Chair to draw up a resolution, subject to the final approval of this meeting, calling the attention of the proper government

official or officials to the necessity of appointing a committee to radically revise the existing rules and regulations of the United States Steamboat Inspection Service.

THE CHAIRMAN:—Any further remarks upon these papers?

REAR ADMIRAL WASHINGTON L. CAPPS, U. S. N., *Vice-President*:—I hope the meeting will not be alarmed at my bringing some documents to the platform with me. I shall only briefly refer to them and shall not take much of your time. I had hoped that this important subject would be thoroughly discussed by the members of the Society. As one who has had somewhat to do with the work of the recent International Conference on Safety at Sea, I confess to a certain disappointment that the subject of the papers has been handled with so much delicacy and restraint. I think this indicates, however, that those who studied it realized that it was a much more difficult and complex question than might appear on the surface.

To proceed immediately with comment on the paper, it is almost needless to state that nothing in ship construction is more important than the preservation of the buoyancy of the vessel in damaged condition. The Committee on Construction which dealt with this subject at the London Conference worked assiduously. At the very beginning there was very far from being any general agreement as to the best means to propose. Three more or less definite schemes had been presented by three of the most important maritime nations, but none of these schemes had been sufficiently developed to permit definite and final determination as to its merits and demerits. As the deliberations of the Conference proceeded, it became evident that we would have to strike out on new lines. The main Committee on Construction was then subdivided, and these sub-committees were given specific subjects to consider, with the result that before adjournment of the Convention this committee was able to report a definite scheme. Even its most ardent advocates, however, would not claim for it anything approaching perfection. Certain compromises were necessary, but it takes more than a casual reading even of the complete report of the Convention itself to determine just what are the good points and the weaknesses of the Convention that was finally adopted.

I think I am safe in stating that the main question as regards buoyancy of vessels under damaged conditions is the "permeability" assigned to different compartments of the vessel, especially where these compartments are subject to varying densities of loading.

The Convention finally adopted owes much to the labors not only of the original British Bulkhead Committee of the early nineties, but also to German, French, and subsequent British research and experience. It may not be known to many of our membership that the "permeability" adopted by the original British Bulkhead Committee, whose technical labors were so splendidly directed by the late Professor Jenkins, was 40 per cent. You will note that, in the "permeabilities" adopted by the Convention, the lowest was 60 per cent. That percentage was only applied to cargo space, whereas the percentage for machinery space was 80 to 85 per cent, and that for passenger and other between-deck spaces was 95 per cent. All double bottoms were allotted a permeability of 95 per cent. A brief consideration of these percentages for "permeability" show how, at the very beginning of our deliberations, we greatly increased the factor of safety. The "permeability of a space" used in this sense is the "percentage of that space which can be occupied by water" under the conditions assumed in the calculations. This means that in all calculations resulting from the provisions of this Convention you must assume that, no matter what your cargo is, 60 per cent of that total space can be occupied by water; and, similarly, 80 per cent of the machinery space and 95 per cent of passenger and between-deck spaces.

Most ships when ready for sea are so laden that in many instances the "permeability" would be much less than that which is assumed as the basis of these calculations. Therefore, under the specific requirements of the Convention, the ship, in many instances, has, as a result of these requirements, a safety factor.

There were individual members of the Conference Committee who were not entirely satisfied with the degree of rigor of subdivision finally adopted, but calculations in specific cases will show that the degree of rigor established by the Committee was distinctly in advance of anything now existing; and, I regret to say, when applied to many of the vessels in this country, would not give satisfactory results.

The Convention covered a very considerable area of endeavor, as you know, and while setting as high a standard as was felt to be practicable at that time, it provided numerous avenues for still further improvement of conditions as knowledge was developed. For the benefit of those who at first glance may say that the requirements of the Convention can be easily exceeded, the Committee, after some illuminating debate, incorporated in the Convention an article (Art. X, Regulations) which not only encourages owners and designers to do their very best, but provides the machinery by which they can be given, on the "safety certificate" of the vessel, a mark of merit or efficiency, as it were; in other words, wherever a particular ship in its subdivision exceeds the requirements laid down by the Convention, the owner can make claim to the proper governmental department, and, by furnishing the necessary proof, can have made on his official "safety certificate" an entry of the extent by which that particular ship exceeds the requirements imposed by the International Convention.

It is possible that I am speaking rather more of the Convention than of the papers which have been read this morning, but the papers of course refer especially to the Convention and its work. Right here it may be pertinent to suggest that when our volume of Proceedings is printed, it may be a very good thing to have printed as an appendix the full text of the Convention, so that we may have in our transactions a permanent record of the complete text.

I do not think it necessary to go further into the detail of the papers submitted, which are largely descriptive and refer particularly to the work of the Convention. I may note, however, referring to the abstract of the paper by Mr. Donald, whose preparation has been admirably done, that in excluding coastwise vessels and those operating on the inland waters of any country from the provisions of the Convention, we simply recognized a principle of international law, that international agreements cannot regulate the domestic affairs of other countries. It was clearly and pointedly indicated, however, in discussions, that any country ratifying this Convention, and thereby insisting on certain provisions of safety in their oversea passenger traffic, would necessarily be obliged to make these provisions sooner or later applicable to their own coastwise ships, and if quick action were not taken after ratifying the Convention, I feel quite sure that public opinion would force action.

And now just one concluding remark about unsinkability and the unwisdom of relying too much upon the design rendering a ship unsinkable. The very best endeavor of the naval architect may be nullified by ignorance or neglect on the part of those who operate ships. Many devices are installed on passenger vessels at great expense with the specific purpose of rendering these vessels safer under ordinary conditions of operation. I think it is common knowledge in the experience of many of us that these carefully designed devices are often allowed to become inoperative, or are so used as not to be ready for service when the emergency arises. Therefore, in preparing for the President of the United States a memorandum giving a synopsis of the work of the Committee, the chairman of the Committee on Con-

struction, with the full approval of his colleagues, felt impelled to call attention to the serious obligation still remaining with those who owned and operated ships to do their utmost to render them safe under the ordinary conditions of navigation, as indicated in the following paragraphs taken from the report of the American Commission to the President of the United States:—

"It is not claimed that ideals have been attained; indeed, there is always room for improvement and progress. But a good beginning has been made, and it is believed that the spirit shown by the representatives of the various countries participating in the Conference affords ample evidence that there will follow, through the instrumentalities provided by the Convention, still further developments in ship construction and arrangement which will increase the safety of travel at sea.

"It is well to bear in mind, however, that there can never be absolute safety at sea any more than there can be complete security of travel by land. Even perfection of material, where such is obtainable, must be accompanied by vigilance of personnel and the exercise of careful and prudent seamanship. In fact, we may accept without reservation the absolute accuracy of the following paragraph from the summary of the work of the committee on Safety of Construction, as given in the closing address of Lord Mersey, the President of the Conference:—

" 'It is important to point out that, even after the most careful attention to all practicable details of design which increase the safety of a vessel at sea, there still remains the possibility of a serious and totally destructive accident. Therefore, it is imperative that those charged with the management of vessels should never relax their vigilance on the supposition that any vessel is unsinkable. On the contrary, they should strive to add to the safety provided by the vessel itself that very great increase in safety which results from prudent and skilful management and navigation.' "

THE CHAIRMAN:—Any further discussion on these papers?

MR. THEODORE LUCAS, *Member:*—I should like to ask a question in regard to the table on page 16, that perhaps could be explained in connection with the factors under Column A. It seems that small ships have a factor of 1.00. Does that indicate that there would be no bulkheads at all in these small vessels, or would it be exclusive of the bulkheads perhaps at the bow or collision bulkhead and the machinery bulkheads?

It is gratifying to see the interest at the present time that is given to the subdivision of ships. I had the pleasure about fourteen years ago to present before this Society a paper in which I drew attention to the great lack in that direction, particularly subdivision and also stability. We have recently had an accident upon the St. Lawrence River where the collier Storstad ran into the steamer Empress of Ireland, and the ship heeled over and went down through loss of stability rather than lack of subdivision. It would seem wise that some attention should be given to this question of stability, because it would not be so difficult to establish for a ship certain standards of heeling capacity to which the ship could be measured under different conditions. We note here in these subdivision tables that they do take care of different character and density of cargo. That could be applied as easily to the other, and perhaps a reasonable factor will result.

A member suggested that a committee might be appointed from the membership of the

Society, and I mention this matter now because I think the same committee could look into this question also, and I think it certainly would be worthy of attention as much as the question of the subdivision of hulls.

THE CHAIRMAN:—We will not have time to discuss the suggestion made by Mr. Gardner that a committee be appointed, as that is a matter which may better be taken up and determined by the Council.

MR. H. L. DES ANGES, *Member* (Communicated):—I am very grateful to Mr. James Donald for his paper on the application of the subdivision rules, which not only the Society but the public at large have been in need of for some time. I have been a strong advocate of this principle, it has been exemplified in all of the designs which I have been associated with during the last twenty years, and I have regretted that there has not been a more general recognition of the principle.

In looking over the new rules prescribed by the Steamboat Inspection Service of the Department of Commerce, I have regretted to note that they have given so much attention to what might be considered the cure rather than the prevention—as the old adage ran: "An ounce of prevention is worth a pound of cure," the cure being the forcing of life-saving appliances, which they had adopted, to an irresponsible or an unseaworthy vessel.

I am sure the Society should be complimented upon the acquisition of this paper, and I extend my personal thanks for the efforts of its author. I heartily commend his suggestions.

THE CHAIRMAN:—If there is no further discussion, we will call for the closing by the authors. Mr. Chamberlain is not present, but we will be pleased to hear from Mr. Donald in closing the discussion on his paper.

MR. DONALD:—In reply to Mr. J. Howland Gardner's inquiry in regard to permeability, I used the factors of permeability as outlined in the International Conference. In reply to his question asking my opinion as to the practical correctness of these factors, we have just heard from Admiral Capps as regards the question of permeability, and I agree with him that there will be in most cases a safety factor if the recommendations of the International Convention are carried out. I am, therefore, of the opinion that the factors suggested are practically correct.

I am quite in agreement with Professor Sadler when he draws attention in the first paper to Mr. E. T. Chamberlain's suggestion to have a staff of well-trained naval architects to work with the Department of Commerce, in carrying out the requirements of the International Convention. Instead of going to the trouble and expense of getting up detailed rules for subdivision, load line, and seaworthiness of ships for every possible trade, I believe more satisfactory results would be obtained by having a small staff of trained naval architects to investigate and make recommendations for all types of vessels submitted for approval.

There might be general rules provided by the authorities in charge of the inspection of steam passenger vessels, but in detail this small staff of trained naval architects would have authority to pass upon and approve the subdivision and arrangement of vessels.

Before I left London, about two weeks ago, I had an interview with Naval Constructor McBride, who was associated with Admiral Capps on the commission in London, and he mentioned, as Admiral Capps has done, the importance of Article X of the International Convention, an article which refers to the case where the degree of safety of a vessel is greater

than that prescribed by the Convention. I desire to include this article so as to complete the paper on Subdivision.

I would like to draw the attention of the members to the title of the paper, viz.: "Application of Subdivision Rules." I am rather disappointed that we have not heard from more of the shipowners and marine superintendents. I thought that some of the examples I took would have brought about some discussion with regard to the coastwise ships that are running now. Perhaps it is a delicate subject with the principals and also with some of the superintendents, but I thought we would have heard something from the marine superintendents as regards the application of the International Rules to coastwise trade.

I thank Admiral Capps for his kind remarks about the paper, and I think we all ought to feel proud of the results of the International Conference as regards Construction, the division of which Admiral Capps was chairman. The proceedings of the division of the Convention which he so carefully and successfully guided have resulted in the splendid recommendations for more safety of life at sea.

Mr. Theodore Lucas asked for an explanation regarding the table on page 16. I drew attention in the paper to the fact that the Convention required the spacing of watertight bulkheads on "mixed cargo and passenger" vessels, 571 feet in length and above; and, in "passenger vessels," 489 feet in length and above. Naturally, for the smaller vessels the factor was increased. Steamers are nearly all classed in some classification society; such society would require that a vessel must have a collision bulkhead, a bulkhead at each end of machinery space, and an aft peak bulkhead. With such an arrangement of bulkheads there is a length of ship where the vessel would float with any one compartment filled. We therefore obtain the factors as in column A on page 16, and no steamer would be built without bulkheads.

THE CHAIRMAN:—I would say further, in regard to the suggestion of Admiral Capps as to the publication of the text of the Convention—that it be published with our Transactions—that that matter may also be taken up by the Council.

I do not know that it will interest you at all, but I happened to be in London at the time of the opening of this Conference, and no matter how early I got down to breakfast at the hotel I always found Admiral Capps there; and no matter how late at night I returned to the hotel, I found Admiral Capps busy with a committee, or occupied in some other work in connection with the Conference, so it was apparent that he was working nearly twenty hours out of the twenty-four. We are to be congratulated that we had men like Admiral Capps doing such important work at the Conference in London.

If there is no further discussion, I wish to tender to Mr. Chamberlain, an efficient member of the delegation sent from the United States to London, your thanks for his paper, and also to extend our thanks to Mr. Donald for the most excellent paper which he has presented to us.

We will now have the paper entitled "Safety of Life from Fire at Sea," which will be presented by Mr. W. O. Teague.

Mr. Teague presented the paper.

SAFETY OF LIFE FROM FIRE AT SEA.

By W. O. Teague, Esq., Visitor.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

Safety first! These words of warning are rapidly becoming familiar, particularly to the traveling public of the United States of America, due to the wide publicity being given them by Chambers of Commerce and other public-spirited organizations. Printed signs bearing the warning are being prominently displayed on railway trains, street cars and other means of conveyance on land, but I have not seen or heard of such signs appearing to any appreciable extent on ocean steamers and vessels carrying passengers on the rivers, sounds and lakes of this country. It would seem, therefore, that the safety campaign has not as yet been extended to this field, which involves great possibilities of serious injury and loss of life to travelers on water. There is no one means which to-day offers such great opportunity for increasing safety from fire at sea at small cost as the general introduction of automatic sprinklers on shipboard, these to have an open connection to a source of water supply so as to be always instantly available.

The greatest sources of danger are shipwrecks and fires. Improvements in the construction of vessels, life-saving and signaling apparatus, particularly wireless telegraphy, and the adoption of stringent rules and regulations governing navigation have gradually reduced the losses from shipwrecks, but there has been little progress made in safeguarding life from fires.

The awful cry of "Fire" is always terrible and startling, but more so on shipboard, where every circumstance of danger and horror is intensified. Most vessels are still largely constructed of wood, and although the advent of steel for the hull, and in some cases decks and bulkheads, has reduced the amount of inflammable construction, the fixtures and contents are still composed of combustible materials; and when fire starts, particularly at sea, it often consumes the vessel or causes it to sink. The passengers meanwhile have little choice between death by fire or drowning.

LOSS OF LIFE.

Statistics regarding loss of life from fires at sea are fragmentary.* Records of the United States Bureau of Navigation, Department of Commerce and Labor, show the following losses of life on American steamers:—

Year ending June 30,	Number of steam merchant vessels totally destroyed by fire.	Number of lives lost on these vessels.
1906	53	12
1907	56	48
1908	58	5
1909	57	16
1910	93	23
Total	317	104

It should be noted that the loss of life given above is only that which occurred on vessels totally destroyed, whereas the probable loss of life on vessels only partially destroyed is equally large. Figures are not available previous to 1906, but, if we include the 957 lives lost on the General Slocum in 1904, it would bring the average number of lives lost by fire on American steam merchant vessels alone, for the seven years noted, up to 200 per year.

These statistics also show that the average number of American steamers totally destroyed by fire each year is over 60, while in addition there are about 140 vessels of miscellaneous type destroyed, making the total average 200 per year.

The number of vessels completely destroyed by fire may not seem large when it is considered that throughout the world there are probably 50,000 vessels continually in service. At the same time the possible loss of life and probable destruction of property consequent on fire should encourage serious consideration of all possible methods of preventing outbreaks and arresting fire in the early stages.

The following is a list of passenger vessels destroyed by fire resulting in serious loss of life at sea, not including fires following shipwrecks; two disasters which occurred before the eighteenth century being included so that the table may serve as a historical reference:—

*From "Some Suggestions for Reducing the Loss by Fire on Vessels," by Samuel D. McComb, Volume 18.

Name of vessel.	Date burned.	Location.	Passengers and crew.	Lives lost.
New Horn	1619	Off Madagascar		200
Prince	July 26, 1752	Off Portugal		300
Kent	Mar. 1, 1825	Atlantic Ocean		96
Ocean Monarch	Aug. 24, 1848	Off Lancashire	218	178
Amazon	1852	Bay of Biscay	162	104
Austria	Sept. 13, 1858	Atlantic Ocean	538	471
Japan	Dec. 1873			391
Wawassett	Aug. 8, 1874	Potomac River		82
Cospatrick	Nov. 18, 1874	Atlantic Ocean	476	473
Seawanhaka	June 28, 1881	East River, New York		40
General Slocum	June 15, 1904	East River, New York	1,388	957
Volturno	Oct. 19, 1913	Atlantic Ocean	657	136

TYPICAL FIRES.

A brief reference to several of these fires will illustrate general experience. The British steel steamship Volturno was abandoned on fire at sea October 10, 1913, in the Atlantic Ocean en route from Rotterdam to New York, and later was scuttled. There were 136 lives lost out of 657 passengers and crew.* The vessel was loaded with a general cargo consisting of chemicals, oils, rags, peat moss, straw bottle covers and mats, and large quantities of wine and spirits, all highly inflammable goods. The fire started in one of the forward holds and was fought with water from hose streams and steam. The hatches were burned so that the steam had practically no extinguishing effect, and, as the crew were unable to direct the hose streams on the fire, it continued to burn itself out. The holds were not flooded for fear of foundering, as there was a very high sea running, which also prevented the lifeboats being launched from the Volturno or the several liners which had been summoned to her aid by wireless. Oil poured on the waters by the tank steamer Narragansett the following day finally permitted the rescue of those still alive.

The wooden steamer Amazon was burned in the Bay of Biscay in 1852, on her first voyage. The loss of life was 104 out of 162.† Fire started during the night time in the engine-room from overheating of the engine bearings, and its rapid spread prevented the engineer from shutting off steam, so that the vessel continued at a speed of some thirteen miles per hour. This made it impossible to launch the lifeboats until the steam supply was exhausted. Several boat-loads were gotten away, and these were rescued later.

*From "The Burning of the Volturno," by Arthur Spurgeon.
†From "Great Shipwrecks."

Probably the greatest loss of life from fire on shipboard was caused by the burning of the paddle-wheel excursion steamer General Slocum, June 15, 1904, in the East River, New York. The total loss of life was 957 out of 1,358 passengers and 30 crew.* The vessel was of wooden construction throughout, with three decks. The light wood of the upper decks had been painted and varnished many times and was therefore in a highly inflammable condition. In the construction of the vessel there were no safeguards against fire other than compliance with the regulations as regards the proximity of woodwork to boilers. The vessel had no fireproof hatches or bulkheads. In such a vessel a fire, once having obtained fair headway, could not be controlled and the vessel would be quickly consumed, as occurred in this instance.

The fire started in the forward cabin, so called, this being the third compartment under the main deck from the bow, and probably originated in a barrel containing packing hay, communicated to it through the carelessness of some unknown person. This cabin was used as a lamp room and general storage room. At the time of the disaster it contained four barrels of cylinder, machine and mineral oil, also a large number of paint pots and kegs and various other ship's stores and rubbish. In brief, this cabin was in an excessively unsafe condition as regards fire.

There were available on the main deck for fighting this fire a line of cheap linen fire hose supplied with water from a good steam fire pump and twenty fire buckets which were empty when fire started. The hose burst and was rendered useless upon turning water into it. The fire spread rapidly and the vessel was beached, but in the meanwhile the people were obliged to jump overboard. It was learned later that no fire drills or boat drills had taken place on the vessel that year. The inefficiency and poor quality of the deck crew, doubtless typical of the majority of the crews of excursion steamers, was one of the essential facts that caused the loss of so many lives. One of the fundamental facts which made possible a disaster of so extreme a nature was the character of the material and form of construction of the General Slocum, and in this respect the Slocum was no more dangerous than are scores of steamers still carrying passengers in the port of New York and hundreds of similar vessels elsewhere. The sole protection of such a vessel against fire depends on prompt extinguishment at its early inception.

CAUSES OF FIRE.

The most frequent causes of fires on passenger steamers are: Spontaneous combustion of coal in the bunkers and of certain materials in the holds and storerooms; the ignition of volatile oils in the storerooms, such as gasoline, alcohol, turpentine, etc., by the striking of matches, breaking of incandescent electric lamps, tipping over of oil lanterns and candles, or other open flame; ignition of woodwork or other combustible materials in contact with steam pipes, uptakes and stacks, defective electric wiring, and burning cigars, cigarettes and matches.

*From Report of the United States Commission of Investigation.

PREVENTION OF FIRE.

The first essential for the prevention of fire is the use of non-combustible material in the construction of the vessel and its fittings. The hull and important bulkheads and decks of ocean liners are made of steel and this construction is used for the better class of coastwise, sound, lake and river steamers. The greater portion of passenger and crew space of all these vessels is combustible, however, and the partial use of steel has not materially lessened the possibility of destruction by fire.

It is entirely practicable to substitute light steel for wood, but thus far the increase in cost of about 10 per cent for medium and large passenger steamers has been considered prohibitive. The only other objection raised to the use of steel is that a uniform temperature below decks cannot be readily maintained except by artificial ventilation. There are non-combustible insulating materials now available to line the steel, which construction gives good results. Wood carvings, panel work, etc., can also be duplicated in metal for partitions and furniture. Plaster of Paris and similar materials are now used in modern liners for decorative effect.

A number of paints have been claimed to fireproof wood and thus remove this objection to its use, but this claim has been discredited since tests have demonstrated that, while the paint retards somewhat the ignition of the wood, it does not reduce its combustibility in the least.

The next important feature of prevention is to subdivide the vessel into comparatively air-tight compartments, and fortunately the design of passenger steamers lends itself readily to this construction. The watertight bulkheads, both transverse and longitudinal, form fire stops similar to division walls in factories. The decks still further retard the spread of fire, especially when made of steel, and the small cabins and other compartments with non-combustible enclosures confine a fire so that it may be readily extinguished if proper facilities are available. Fireproof doors should be fitted to all important door openings, and these should be normally closed or be automatically self-closing in case of fire.

Where wooden decks are used, a clear space should be left where the funnels pass through and the exposed wood faced with asbestos and sheet steel. Similar protection should be provided for galley stove-pipes. Combustible goods of all sorts should be kept away from these flues and other hot pipes and stored in fireproof compartments. The galley should be lined with metal and have a non-combustible flooring. The safest location for the galley is on an upper deck.

Cleanliness of the vessel is very important, and particularly in the case of storerooms, lockers, etc. The engine-room should be kept free of excess oils and the supply of these limited. Oily waste should be stored in metal waste cans of approved type until removed.

Lamp rooms are required by law to be metal lined and have an oil-tight floor. When oil lamps are used they should have metal bodies and be securely fastened in place. Any woodwork over them should be protected by metal shields. Torches are

much used in the engine and fire rooms but are not very hazardous if not left lighted.

Electric light wires should be run throughout in approved iron conduit. Switchboards should be of slate or other non-combustible material and be set clear of woodwork back of them, which should also be fireproofed with steel or asbestos or both.

FIRE PROTECTION.

The most effective fire-extinguishing agent, water, is of course always available in unlimited quantity, but to obtain the best results it must be properly applied.

Flooding.—The simplest method would be to immerse the burning vessel, but this can be done only to a limited extent because of the danger of foundering and drowning of all on board. Before the days of steam machinery, water from outside was allowed to fill that portion of the vessel in which the fire occurred, but this did not prove efficient since the water level could not rise sufficiently to submerge the entire hold and its contents, and the fire was thus permitted to spread to other portions of the vessel. In the case of the Volturno none of the holds was flooded for fear of foundering, which demonstrated that this method of extinguishment is not always practicable and that it is quite inefficient.

Fire Pails and Chemical Extinguishers.—For incipient fires the water bucket has always been useful, and even to-day it forms an important part of the fire-protective equipment on shipboard and also in factories and miscellaneous buildings ashore. The records of the Associated Factory Mutual Fire Insurance Companies show that fire pails extinguish the majority of fires occurring in some three thousand factories insured by them.

The so-called chemical extinguishers have also come into use on shipboard in addition to the fire pails, and sometimes improperly in place of them. There are several types of these extinguishers, the principal ones being the two and one-half-gallon soda and acid extinguisher and the smaller, usually one quart, extinguishers utilizing carbon tetrachloride liquid as the extinguishing agent. The soda and acid extinguisher is in principle a water pail arranged to more effectively distribute the water under pressure. The addition of the chemicals does not increase the efficiency of the liquid to any appreciable extent. The principal weakness of this extinguisher is that it may not be in an operative condition when needed, but this can be largely remedied by occasional inspection and test of it.

The tetrachloride extinguisher depends upon the smothering effect of the chlorine gas, which is liberated when the liquid comes into contact with the flame, for extinguishment, and the extinguisher is effective only in small enclosed spaces such as lockers, etc., where the gas can be confined. The liquid has but little cooling effect, especially since it evaporates rapidly, with the result that the embers will again burst into flame, thus requiring constant use of the liquid to insure complete extinguishment. The chlorine gas also renders the use of the extinguisher impossible in large spaces where the firemen have to gain access to reach the fire. For

these reasons the tetrachloride extinguisher should only be depended upon to extinguish incipient fires in enclosed spaces.

Hose Streams and Fire Pumps.—Manually operated pumps and later steam pumps with fire hose have proven effective when brought into use before the fire has assumed large proportions. The discovery of the fire usually takes place after it has gained considerable headway, and the consequent delay in bringing the fire hose and pump into use forms a serious weakness of this method of protection. Furthermore, it is difficult and frequently impossible to direct the streams at the source of the fire because of the inaccessibility of numerous parts of the vessel's compartments and the inability of the firemen to withstand the smoke and heat at a point near enough to apply water. The hose streams are very effective, however, as a secondary line of defence in preventing the spread of fire by wetting and cooling down the structure contiguous to the burning area, and as a means of final extinguishment after the fire has been gotten under control.

The arrangement of the system proposed by the International Convention for the Safety of Life at Sea provides that every vessel shall have powerful pumps; on vessels less than 4,000 tons there shall be two, and on larger vessels three of these pumps. The capacity of the pumps shall be such that they can deliver a sufficient quantity of water in two powerful jets simultaneously in any given part of the vessel. The fire service mains are to be arranged so that two streams can be simultaneously directed on any given part of a deck occupied by passengers and crew, when the watertight and fireproof doors are closed. Provision is also to be made so that two streams may be conveyed to every space filled with cargo.

Steam.—The advent of the steam engine and steam turbine for propulsion of vessels made steam available for fire extinguishment. The steam extinguisher was first favored and required by the United States Government for use on passenger and freight steamers, and it is now in general use for the protection of cargo spaces on steamers of practically all nations.

The General Rules of the U. S. Steamboat Inspection Service requires the following arrangement of steam-extinguishing apparatus for ocean, coast-wise, lake, sound and river steamers. "The main pipes and their branches, on steamers carrying passengers or freight, to convey steam from the boilers to the hold, and separate compartments of the same shall be not less than 1½ inches in diameter. * * * Steam pipes of not less than ¾ of an inch in diameter shall be led to all lamp lockers, oil rooms, and like compartments, which * * * compartments in all classes of vessels shall be wholly and tightly lined with metal. All branch pipes leading into the several compartments of the hold of the vessel shall be supplied with valves, the handles distinctly marked to indicate the compartment or parts of the vessel to which they lead. These valves or their handles shall be placed in the most accessible part of the main deck of the vessel and so arranged that all can be inclosed in a box or casing, the door of which shall be plainly marked with the words, 'Steam fire apparatus.' Pipes for conveying steam from the boilers * * * for the purpose of extinguishing fire, shall not be led into the cabins or into other passengers' or crew's quarters."

Upon the discovery of fire efforts are first made to close the openings to the compartment involved and then open the valve on the steam-pipe to it, the smothering effort of the steam being depended on to extinguish the fire. Experience has demonstrated, however, that it is frequently impracticable or impossible to close the compartment, as instanced in the burning of the Volturno aforementioned, under which condition the steam has practically no extinguishing effect, and even when confined the steam is not a very effective extinguishing agent, especially if used after the fire has gained considerable headway. In fact, tests have been made on shore where combustible materials were completely burned, although enclosed in an atmosphere of steam. Steam pipes were commonly provided in the picker rooms of cotton and woolen mills for fire-extinguishing purposes about thirty years ago, but their practical utility has over and over again been found so small that their use has been abandoned. The effect of steam blown into a closed compartment, like the hold of a ship, would doubtless be greater than in a picker room, but we believe that its real efficiency is greatly overestimated in the popular view.

Steam will damage a valuable cargo as much as water and, besides, it is very wasteful. In one case of fire on an Atlantic liner, in which cotton was burned in the holds, so much steam was used that the engine nearly stopped, thus preventing the vessel from rushing to the nearest port for assistance. Furthermore, since the steam is applied only to the holds, it forms at best only a partial protection.

Gases.—Several gases which are non-supporters of combustion have been used to a limited extent to replace steam, and these have proven to be good fire-extinguishing agents when the fire is confined. The gases are not as effective as water, however, in absorbing heat and have but little cooling effect on the fire.

Carbon dioxide gas (CO_2) is compressed to liquid form in steel tubes containing about 40 pounds, and these are connected to the pipe distribution system. While it can be made on shipboard, the process would be too complicated for quick use and also quite expensive.

The use of the gas is objectionable since it causes asphyxiation, although a person could live a limited time in an atmosphere containing 15 per cent of gas, while 40 per cent is necessary to extinguish fire. A 40-pound tube is required for each 1,000 cubic feet of air space. This objection is not serious, however, as the gas is proposed for use in the holds only, and there is small possibility of any of the crew being in there when on fire. The gas is non-injurious to merchandise.

The arrangement of the pipe distribution system is similar to that for steam previously described. Since the gas is heavier than air the outlets are placed at the ceiling, and in operation the gas will descend through the cargo, filling crevices and interstices which could not be reached by water except by flooding. When the necessary amount of gas has entered the compartment the fire is extinguished, and the gas can then be removed by an air pump piped to the bottom of the hold.

Another gas is sulphur dioxide (SO_2), and this is being exploited to-day for this use. It is said to have been in use for years and to have successfully extinguished fires at sea. An apparatus is on the market for making the gas on

shipboard. Commercial sulphur is burned in a specially designed furnace connected to the holds by a double line of piping. Air is drawn from the holds through one pipe by a high-powered blower and discharged into the furnace, where it is converted into sulphurous gas, which in turn is forced back into the hold through the second line of piping.

Thus oxygen is replaced by non-combustion supporting gas. When the gas contents have reached a certain percentage the burning sulphur is cut off, and the gas-laden air in the hold is circulated by the same machine through a cooler which forms its base, and fresh air is gradually admitted. The cooling-down process can be observed and regulated at the machine.

So-called fire indicators are fitted to the machine with connections to the chart room. In operation air is drawn from the various holds and any rise in temperature is indicated. It is claimed that this machine is now used on vessels of 2,000,000 tons gross tonnage.

The gas has been considered objectionable since it causes asphyxiation, an atmosphere containing only 3 per cent of the gas being fatal to life. This is the same suffocating gas of which one gets a whiff from the burning of an old-fashioned brimstone or sulphur match, and it is liable to be of greater efficiency in quickly extinguishing the breathing power of human beings anywhere in the vicinity than in extinguishing fires. It is also said to be injurious to certain kinds of merchandise since it is a powerful bleaching agent.

The use of nitrogen gas has also been experimented with. It is made by forcing air through a confined burning body, whereby instantaneously the nitrogen and oxygen of the air are disengaged and free nitrogen with an occasional trace of carbon dioxide gas given off.

The boilers of steam vessels at sea are constantly producing and discharging through the smoke-stack a similar mixture. The apparatus which has been designed to utilize these gases for fire extinguishment consists of a blower with suction piped to the uptake flue over the boiler; a cooler made of a coil of pipe water-jacketed and placed in the suction pipe so that the gases may pass freely into the usual pipe distribution system. Valves are provided on pipes to cabins, etc., in which people are apt to be present, so that the gases can be discharged as the rooms are vacated.

The records of the patent offices are overloaded with hundreds of devices for applying various gases for extinguishing fire on shipboard, which it must be instantly recognized as utterly impracticable by all who are familiar with the art of fire extinguishment or with conditions on shipboard.

Automatic Sprinklers.—In the foregoing I have briefly outlined the history of fire protection on shipboard and described present general practice. The automatic sprinkler, which has been in use particularly in factories during the past thirty years, has proven to be a great conserver of life as well as property. The records of the Associated Factory Mutual Fire Insurance Companies show that since 1874 there were only five lives lost by fires in about 3,000 factories thus protected. There are employed in these factories 1,500,000 people. In all the factories equipped with

sprinklers in the United States and Canada there are 2,225,000 employees who are safe from fire. The fire records show, however, an appalling loss of life in factories not protected by automatic sprinklers.

In spite of these well-known facts the application of this safeguard to vessels has only just begun, the delay doubtless being due to the additional expense of a sprinkler system, there being no direct return on the investment. The estimated cost of a sprinkler equipment on shipboard, exclusive of the pumps and tanks, would be about $4 per sprinkler, these being spaced about 10 feet apart, each one protecting 100 square feet.

The automatic sprinkler is in principle a ½-inch globe valve having a soldered link or strut to hold the valve disc tight on its seat against water under pressure in the pipe system. The sprinklers are located near the ceiling and spaced about 10 feet apart. In event of fire the solder melts, releasing the valve cap, and water is distributed all around in a dense spray. Where the compartment is not heated in winter, as in storehouses or the holds of vessels, the pipe system is maintained under air pressure at about 35 pounds, a special device, termed a dry-pipe valve, being installed in the main supply pipe in a heated enclosure to hold back the water until fire opens a sprinkler, when the valve trips and water is permitted to flow into the system.

On shipboard the water can be maintained under pressure by continued slow operation of the steam fire pump, using an automatic governor or a large tank nearly filled with water with air above kept under pressure by intermittent operation of a small air pump, the fire pump to be started as soon after discovery of fire as possible.

The limited capacity of the pressure tank and the possibility of the air pressure lowering are sources of weakness, but it seems entirely feasible to overcome these on large ocean liners by the use of a gravity supply by providing a tank built in the form of an extra funnel. For steamers with several funnels, large water-jackets could be fitted to them to provide the supply.

There are a number of coastwise, sound and lake steamers already fitted with sprinkler systems, and several ocean liners have partial systems. The steel steamer Alabama operating on Lake Michigan has automatic sprinklers on the dry-pipe system in the holds and passenger and crew quarters. There are 300 sprinklers in all, each of those in the holds covering from 80 to 120 square feet, and one being installed in each inner stateroom and a number in the hallways, stairways, locker spaces, etc. Sprinklers were not provided in the outer staterooms as these are more accessible for the use of hose streams and other appliances.

There are two 2½-inch hose connections on the main deck with 200 feet of 2½-inch hose and fifty 1½-inch hose connections with 2,500 feet of 1½-inch hose distributed over the several other decks. In the engine-room there are the following steam pumps: 1 duplex, 600 gallons capacity; 1 fire engine duplex, 1,200 gallons; 2 single, 180 gallons; 3 feed, 390 gallons; the total capacity being 3,330 gallons per minute. On the forecastle deck there is a hand deck and fire pump of 50 gallons capacity.

The steel and wooden steamer Commonwealth operating on Long Island Sound has 1,800 automatic sprinklers distributed throughout the interior of the steamer, staterooms and lockers, not exceeding 8 feet from center to center in any place. This system is divided into thirty circuits, each with a 4-inch diameter main from a manifold located in the engine-room on the main deck.

To this manifold the main discharge from a 16-inch by 12-inch by 12-inch duplex fire pump is connected. This pump at all times maintains a pressure at the manifold of 100 pounds per square inch and is fitted with a governor to maintain this pressure in case of the opening of any of the circuits and sprinklers, and is also fitted with a throttle by-pass which can be operated from the main engine-room.

Supplementary to this system is a thermostat system with mercury thermostats located not over 12 feet centers with all wires run in conduit, and divided into circuits corresponding with the sprinkler circuits. This system terminates at two annunciators, one in the main saloon and one in the engine-room, indicating the circuit number. The opening of a valve of corresponding number on the sprinkler system manifold supplies water to the sprinklers at the fire.

In addition to the two main annunciators on the thermostat system, small annunciators are located throughout the saloons to determine the location of a fire within a range of a few staterooms. All the annunciator drops, besides showing the circuit number, indicate the location on the steamer and ring 8-inch alarm bells located in the crew's quarters, engine-room and saloons.

While this sprinkler system will undoubtedly prove efficient if the valve is opened while the fire is in an incipient condition, the chances are that there will be some appreciable delay and the fire be beyond control. It must be borne in mind that the great efficiency of sprinklers on land has been due to their automatic and immediate action, which can only be accomplished by maintaining the system under water pressure or where there is liability of freezing by maintaining air pressure in the system, using a dry-pipe valve. Experience has shown that the slight delay in discharge of water with the dry-pipe system does not materially reduce the efficiency of the sprinklers.

There are sixty-five hose connections located throughout the steamer, connected by copper fire mains with the fire and wrecking pumps, a 50-foot length of hose is attached to each outlet, and the location is such that all portions of the steamer are protected. A large donkey boiler located on the main deck is connected to all fire and sprinkler system pumps, and steam is kept up night and day when the vessel is laid up for the winter months or for repairs. A watchman's time detector is connected with thirty-eight recording stations so located that in order to make a proper record the watchman must pass through every section of the ship.

The ocean liners Imperator and Vaterland have 800 automatic sprinklers installed in deck "G" forward from amidships bulkhead to steerage bulkhead and aft from amidships bulkhead to second class cabin bulkhead; in deck "H" forward and aft of the amidships bulkhead. The sprinklered portions of deck "G" are

storage compartments, and in deck "H" the crew's quarters. There are two systems, one forward and one aft of the amidships bulkhead for both decks, and they are connected to and are constantly under pressure from the salt water fire main, although the sprinkler piping is normally kept filled with fresh water. There is an alarm valve on each sprinkler riser which operates an alarm electrically connected with the ship's fire headquarters.

There is an automatic fire-alarm system having 450 thermostats placed in the first class cabins forward of the amidships bulkhead, deck "F"; steerage deck "J"; baggage and cargo compartments, deck "K"; provision lockers in the bow, fire decks; second class cabins, deck "E"; second and third class cabins, deck "G"; and provision and baggage compartments on decks "J" and "K." In addition there is a manually-operated fire-alarm system of 28 break-glass boxes and an indicating board in fire headquarters.

Fire mains extend throughout with hose connections and hose so placed that every part of the ship can be reached. The supply is from fire pumps in the engine-room. Chemical extinguishers are placed in the corridors. A steam system is connected to the holds and carbonic acid gas from the ship's refrigerating system can also be used.

FIRE AND BOAT DRILLS.

In order to safeguard life from fire at sea it is of the greatest importance that the crew be trained to use the fire-protective appliances and also the life-saving apparatus in an efficient manner in addition to providing these facilities. The crew as a whole should be instructed in the use of hand extinguishers and fire hose. A muster list should be prepared and definite stations and duties assigned to each man to insure prompt and systematic use of the protective appliances and apparatus. Fire and boat drills should be held often at irregular intervals to familiarize the men with their stations and duties.

The International Convention has adopted the following requirements covering these matters:—"Special duties for the event of an emergency shall be allotted to each member of the crew. The muster list shows all these special duties and indicates in particular the station to which each man must go and the duties he has to perform. Musters of the crew at their boat and fire stations followed by boat and fire drills respectively shall be held at least once a fortnight either in port or at sea."

It is an unfortunate fact that these precautions are usually considered a useless waste of time and effort, which attitude is probably due to the false feeling of security engendered by the absence of frequent fires on any one vessel, not realizing that the next fire may destroy the vessel; and also, since the owners may not be insistent that the drills be carried out, appreciating that they involve some additional expense in operation of the vessels.

PATROL AND FIRE ALARM SYSTEMS.

The more promptly a fire is discovered, the better chance there is of extinguishing it. Acting on this principle, watchmen patrol the unfrequented portions of a vessel, and to check their movements a recording clock is used with key stations at various points throughout the route.

Avoidance of delay in giving an alarm of fire is likewise important. Electrically operated alarm sytems are the most efficient, either automatic, using thermostats, or manual, or both should be used.

SUMMARY.

I have pointed out serious losses of life from fire at sea, the most frequent causes of fires on passenger steamers, practicable methods of prevention and present-day practice in fire protection of these vessels, together with suggestions for improvements, the most important of which is the use of non-combustible material and automatic sprinklers. There is little doubt but what shipowners appreciate the advantages of carrying out these improvements, but for commercial reasons they cannot afford to do so.

Most owners would take every available precaution against loss of life and property from fire if some inducement were given them such as a subsidy, so that they would not be at a disadvantage with vessels not so equipped. In the course of time practically all vessels would be on the same basis, so that the subsidy could be discontinued.

The fact that some vessels are already protected by sprinklers will gradually come to the notice of the traveling public and it would be entirely proper for the owners to advertise the increased safety of their vessels, with the result that these steamers will be favored with greater patronage, thus making it necessary for the owners of other vessels to do likewise. People now prefer to stay at hotels which are of the fire-resistive construction and have been fitted with modern fire-protective appliances. They also consider the increased safety and comfort of riding in steel parlor cars worth the extra cost. A greater disaster from fire at sea similar to that of the Titanic from collision with an iceberg, the possibility of which is very much greater than the public realizes, would bring about an immediate demand for greater safety and an exclusive patronage for protected steamers on which the possibility of loss of life from fire would be reduced to a minimum.

The new ocean liners in particular are being equipped with larger engines to obtain greater speed and are also provided with more costly fittings to increase comfort at the demand of the public who are willingly paying larger fares to obtain these advantages. Their safety is of even greater importance, and there is no doubt but what this will be appreciated in time and that shipowners will meet their demands as soon as it is practicable to do so.

DISCUSSION.

THE CHAIRMAN:—The paper is now before you, gentlemen. Is there any discussion upon this subject?

MR. WARREN T. BERRY, *Member:*—The paper just presented contains many statements as facts, concerning which there is considerable room for argument.

Probably every one interested in vessels recognizes the danger from fire on any of them at any time. It is doubtful, however, if they will grant that passengers on vessels "have little chance between death by fire or drowning."

This statement does not seem to be justified by experience or statistics. Accident insurance companies are in direct touch with statistics covering loss of life or injury to persons, and, I think, without exception, allow double indemnities for injuries received on common carriers, of which the passenger vessels of this country form a part, and for injuries received in burning buildings, which certainly does not indicate that "there has been little progress made in safeguarding life from fires." Examples of vessels destroyed by fire from fifty to three hundred years ago are in no way comparable with existing types.

Further, in regard to statistics, the paper shows a loss of life in five years, 1906-1910, inclusive, of 104 lives with which the records of the Department of Commerce and Labor do not agree. The Steamboat Inspection Service keep statistics covering the loss of life on all inspected vessels, and their records show for a corresponding period 71 lives lost. They also show that in the year 1905 three lives were lost. In the period from January 1, 1911, to June 30, 1914, 28 lives were lost, or a total loss of 102 persons in ten years, compared with 104 in five years, as given in the paper.

Fire is an ever-present danger on shipboard, as it is everywhere else, but vessels today are not "highly inflammable." United States laws prohibit or restrict the carrying or use of highly inflammable articles on passenger ships.

The experience of the Volturno, where fire was confined and kept in check so that the 650 odd passengers on board were enabled to stay on board something over twenty-four hours, would seem to indicate a condition that exists in comparatively few structures on land.

The use of non-combustible material in the construction of a vessel and its fittings is undoubtedly desirable. It has not yet, however, been demonstrated that it is practicable to substitute light steel for wood in all cases.

This question has been thoroughly discussed before this Society, and many objections have been raised to the use of steel other than the cost and that a "uniform temperature below decks can not be readily maintained." The principal objection is that of weight. On a vessel of our sound steamer class, 365 feet over-all length, the additional weight of steel construction above the main deck, as compared with the present construction, would amount to 450 tons, and it has not been demonstrated that a practical structure of this character can be built at all.

Progress in shipbuilding has shown that a matter of 10 per cent increase in cost, or considerably more than 10 per cent, is not considered prohibitive, if definite and feasible plans for improved structures are presented.

In the construction of the steamers Plymouth and Commonwealth, where fire-retardant bulkheads were installed, light steel construction was abandoned in favor of double thick-

ness wooden bulkheads, lined on both sides with plaster board, covered with galvanized iron, as such construction has demonstrated its superiority over light steel.

On these steamers, cargo spaces, immigrant and crew quarters and galleys are lined with galvanized iron, fastened close to the wooden decks and carlines, with the belief that, weight for weight, this construction is better for fire-retardant purposes than steel alone.

I agree thoroughly that the automatic sprinkler has been a great conserver of life and property, and believe that eventually it will come into very much more general use on shipboard than it is at present.

One of the principal reasons why it has not has been the failure of sprinkler engineers to accommodate their systems to the requirements of shipbuilding. It has been a good deal like finding a horse to fit the shoes rather than making the shoes fit the horse.

The New England Steamship Company have installed sprinkler systems on the steamers Pequonnock, Plymouth, Commonwealth, Massachusetts, Bunker Hill, and Old Colony. These systems are complete and in order to-day on the first three steamers. The ownership of the last three steamers has changed, so I am unable to speak for them.

The additional cost of sprinklers is comparatively small in relation to the entire cost of vessels, but on installations with which I have had to do, the total cost, including pumps and connections, which are a necessary part of the system, has been considerably over $4 per sprinkler—about $7 would be nearer the figure.

The wet-pipe system is prohibitive on vessels of the river, sound and similar types because of freezing and the weight of water in the system.

In cargo spaces freight is stowed practically from deck to deck, and on the steamers Pequonnock, Plymouth and Commonwealth there are approximately 100 sprinklers broken off or damaged by cargo every year. With the absolutely automatic systems advocated, the water damage from this cause alone would be immense.

Our experience with the steamer Pequonnock has led to the abandonment of the dry-pipe automatic system, with which she was originally fitted, in favor of the manually operated valves.

The effect of automatic systems, in case of collision, where damages occur in passenger quarters, has also been considered, and we have, to date, declined to assume the responsibility of adding to the possibilities of panic by flooding damaged portions of the vessel with water from broken sprinkler pipes or damaged sprinklers.

We have also considered it impracticable and unnecessary to install a gravity tank, as pressure is constantly maintained by a steam pump. It is hardly conceivable that any one at all familiar with shipbuilding would consider for a moment the placing of a watertank in the form of an extra smoke-stack, as aside from the total weight to be carried, the weight in this particular form and place would be in the very worst position possible to affect the stability of the vessel. The sprinkler systems on the Pequonnock, Plymouth, and Commonwealth are, therefore, arranged to be manually operated.

A thermostat system is arranged in parallel with the sprinkler system to ring alarm bells and register the location of fire on an annunciator in the engine-room, where there is at all times an engineer on watch whose duty it is to open the sprinkler system valve. The delay in obtaining water at the sprinklers with this system need not be appreciable.

This brings us, however, to a matter which is probably of the greatest importance—the discipline and training of the crew. It has been my experience that fire and boat drills are fortunately not "usually considered useless waste of time and effort," but, on the contrary,

are regarded as a prime essential for the safety of the ship, and I believe that owners and managers of vessels in the United States to-day are keenly alive to this fact; and, moreover, that officers and crews of American steamers fully appreciate their responsibility in this regard and live up to it.

Mr. W. D. Forbes, *Member of Council:*—Having had experience in installing sprinklers and testing them, I will say that I do not think that the operating conditions of a sprinkler system aboard ship and on shore are comparable. I agree with Mr. Berry that the panic resulting from the opening of a sprinkler and the flooding of a state-room would be serious. I thoroughly believe in a system, which is an old one, in which an electric indicator shows where there is excessive heat, and the use of perforated water-pipes controlled by valves in the engine room affords infinitely better protection than can be obtained by any automatic system. A dry-pipe system is of very little value in shore work under most conditions. The real value of the sprinkler is to put out an incipient fire—you can spit on a match, which is blazing, and put it out. That is the theory of the automatic sprinkler. In the modern factory and similar buildings the automatic sprinkler system is of great value, where the water can reach the fire and put it out quickly, but in cargo vessels, vessels whose holds are filled with boxes and things of that sort, the water is not apt to reach the fire early enough to prevent a conflagration. That is the fundamental idea of the sprinkler—to put out the fire quickly. Therefore the flooding of the compartment is of very great importance.

I had the pleasure of meeting Captain Inch, of the S. S. Volturno, a few days after he arrived in New York, after the burning of his ship, and I spoke to him about sprinklers. He said that no amount of water could have possibly stopped the conflagration, although it was discovered early, on account of the position of the cargo protecting the fire. I think, Mr. Chairman, that the automatic sprinkler system is not as practical on board ship as the perforated pipe system.

Mr. John A. Stevens, *Member:*—I wish to be recorded as being heartily in favor of the maximum protection of human life and property at sea by the most complete automatic sprinkler system which can be devised, in both passenger and cargo vessels, and I believe that we have reached a state of civilization where we can demand such protection. Further, most of us are willing to pay the additional price for our transportation which would be necessitated by such an innovation.

Mr. I. G. Hoagland, *Visitor:*—In discussing the question of water supplies to automatic sprinkler systems in ships, it should be remembered that the word "automatic" has a double meaning. The sprinkler device itself is always automatic in approved automatic sprinkler systems, and inside buildings the water supplies are always automatic in approved systems. In ships the sprinkler devices would not be less automatic if the water supplies were controlled manually, and while such an arrangement would not be, strictly speaking, an automatic sprinkler system, the advantages of the arrangement would be that the sprinklers would find the fire, as it were, and just enough heads would open over the area of the fire to allow a sufficient discharge of water to control the blaze. Such a way of controlling fires is in sharp contrast to the usual method of extinguishment by submersion, by raising the water up to the fire and flooding the flames. It is obvious that water discharged through automatic sprinklers above a fire will control a fire with much less expenditure of energy and water than by partially sinking a ship to reach the heart of a blaze.

THE CHAIRMAN:—If there is no further discussion, we will call on Mr. Teague to close.

MR. TEAGUE:—I would like to say a few words at this time regarding two or the matters which Mr. Berry discussed. I am strongly of the opinion that the sprinkler system with a manual operation is highly inefficient, and I think it gives a false sense of security. The great value of the automatic sprinkler is in the fact that it is automatic. The automatic sprinkler was intended, when first originated, to take the place of the "first aid" in fire protection, and that was the fire pail. In factory work the mill operatives know what the fire pail is for, and they know how to use it. During the day the operatives are in the factory, and in case of a fire starting during that time there is seldom occasion to have the automatic sprinkler come into play, but fires occur in concealed places during the working hours, and they are also apt to occur during holidays, Sundays, and at night time, when the employees are not present. Therefore, to continue the "first aid" protection, something automatic, which would approach the manual operation of fire pails, was developed, and this was the automatic sprinkler. In order for a fire to be put out by the use of fire pails or other hand extinguishers they must be used promptly while the fire is in an incipient condition, and the same thing is true of the automatic sprinkler.

Where the sprinkler is on a system which is ordinarily dry and the operation of it depends on the opening of valves in the pump room, there is bound to be a delay, and that delay, even if a matter of only a few minutes, may be a serious one. For instance, in the case of a steamer of the Commonwealth type, we have a similar arrangement of woodwork to what exists in a large frame building on land, but we have worse conditions as regards the hazard to life. When the structure is on land, and a fire occurs, the people have a chance to get out, to get on to the adjoining land and escape, but it is not so easy to get away when the building, that is, the steamer, is on the water. Of course, life-saving appliances, such as lifeboats, life preservers, etc., are at hand, but it has been demonstrated in experience after experience that the people can not get off the vessels, especially during the night time or when the water is very rough, and also when the crew is not drilled in the use of life-saving appliances. In my opinion the installation of such a system as that on board the Commonwealth is a step in the wrong direction. If trouble does come, it will count against the standing of the automatic sprinkler, which it should not do, because the automatic sprinkler in that case is not properly installed for the best efficiency.

As to my suggestion that a gravity supply could be arranged for on large passenger steamers by such an arrangement as an extra stack, built for use as a gravity tank, of course the placing of water at that height is objectionable as regards the stability of the vessel, but in my opinion the total weight of that water, as compared with the total weight of the vessel, is almost negligible ——

THE CHAIRMAN:—What do you consider the total weight of water to be in that case? Take a steamer like the Commonwealth, for instance. That is an important matter for the naval architect to understand—what would be the least quantity of water you would have in the tank; how many thousand gallons.

MR. TEAGUE:—For a steamer of the Commonwealth type I think we should have about 5,000 gallons.

THE CHAIRMAN:—That would make for water, tank and fittings at least twenty-five tons up in the air about sixty feet above the surface of the water on a boat drawing but thirteen and a half feet of water. That would be a serious matter for a steamer like the Commonwealth, which has now ample reserve stability, but it would be more serious for many ocean liners.

MR. TEAGUE:—What is the total tonnage?

THE CHAIRMAN:—It is not a question of tonnage, it is a question of stability. Pardon me, I want to get you straight on the difference between tonnage and stability.

MR. TEAGUE:—I thank you very much.

THE CHAIRMAN:—Evidently you do not understand the question of stability. The meeting will kindly forgive me for interrupting at this particular point, but it is evident that Mr. Teague, not being a naval architect, does not understand the difference between the tonnage and the stability of a vessel, and I would like to put him straight, in order that he may discuss the subject from the standpoint of the naval architect.

MR. TEAGUE:—I think this remark is hardly pertinent, since I am a naval architect by training and several years' experience. During my work in fire protection, if I have strayed from the principles and theory of naval architecture, I am not surprised.

The second speaker brought up the point regarding the use of automatic sprinklers and referred to their use on cargo vessels. My paper was intended only to cover passenger steamers, and I have not gone into the matter of cargo vessels at all in this paper. I do wish to bring out the fact strongly that I have not laid claim to the automatic sprinkler as the only means of protection on shipboard. I have tried to bring out the point that the automatic sprinkler is the best form of protection, but in addition to that some value should be placed upon the use of gases and steam. I thank you very much, Mr. Chairman.

THE CHAIRMAN:—The question of danger from fire on board of vessels seems to come up perennially in this Society, and very properly, too, I suppose, but the remarks of the author of the paper just presented in closing the discussion calls to my mind some figures given at the 1910 meeting, Volume 18, as to the danger from fire on board of vessels. I have sent for a copy of the Proceedings of that meeting. You will recall that the speaker just said that we have on a steamer like the Commonwealth, for instance, a situation comparable to that of a frame building on shore. In the City of New York frame buildings are few and far between. If they exist they must be sixty or seventy years old and it is a curious fact that fires rarely occur in them.

The fires in the City of New York occur in brick or stone buildings, or in so-called fireproof buildings. In our Transactions for 1910, page 215, can be found certain figures. In the years 1908, 1909 and 1910—at that time the only years for which the information could be obtained from the Fire Department of the City of New York—there were in this city 227 lives lost in fires, while in the same three years on board of all of the vessels inspected in the United States there were lost by fires the lives of 7 passengers and 43 of crews, 50 lives in all.

In the City of New York there are 5 million inhabitants, or for the three years 15 millions of people to be counted, of which *227* lose their lives by fires. For the same period the vessels of the United States recorded the carrying of 1,009 millions of passengers, not counting the crews or the millions unrecorded as on ferry and excursion boats, and only 50 lives lost by fire—15 per million in the city and .0033 per million on vessels.

I deprecate the alarm caused by the frequent calling of attention to the so-called great danger from fire on board vessels. There is danger in all walks and occupations of life and it can not be entirely eradicated. That comparatively so few lives have been lost by fire on our steamers is most remarkable, but anything that naval architects and marine engineers can do to make steam or other vessels safer will be done, I am sure, for they have this subject always in mind.

Mr. W. T. Berry (Communicated):—I am of the opinion that the sprinkler systems on the steamer Commonwealth and the other steamers similarly equipped, which I have referred to, do not convey any false sense of security. These steamers are fitted with fire pumps from four to five times the capacity required by law exclusive of the sprinkler pumps, and we still place great dependence on this equipment with its connections to fire hydrants fitted with 2½-inch diameter hose. In various buildings in cities where ideal sprinkler systems are installed, we believe that similar equipment of the regular city fire department is frequently required to extinguish fires.

There are many conditions in holds of steamers stowed with freight with which I do not believe any sprinkler system can cope. The sprinkler systems on these steamers were installed with the idea that it was a step in advance and that, should the occasion arise, they might be of use in saving life and property.

I agree thoroughly that the ideal sprinkling system should be entirely automatic, but, for the reasons stated in my previous discussion, do not consider either the wet-pipe or dry-pipe systems feasible on these steamers, and certainly did not consider any reputation records which sprinkler patentees might be trying to make for their particular appliances.

Mr. Teague (Communicated):—Taking up in turn the various features discussed by Mr. Berry, I have the following comments to make on those which I did not refer to in my discussion on the floor.

The fact that the passengers and crew of the Volturno were obliged to remain on board the burning vessel for over twenty-four hours is evidence that they had little choice between death by fire or drowning, and that all these people were not lost was due only to the slow spread of the fire which finally permitted rescue when nature intervened and the high seas calmed down. The people lost on the General Slocum, comprising 70 per cent of the total, were not so fortunate, since the fire spread rapidly, and escape was impossible even on the comparatively calm waters of the East River. It is evident that this serious danger exists whenever the seas are too rough to permit the use of the lifeboats, which is frequently the case at sea or when the crew is not competent.

While it is true, as Mr. Berry states, that accident insurance companies allow double indemnities for injuries suffered while traveling on common carriers and while in burning buildings, he is incorrect in using this as an argument to prove that the hazard to life under these conditions is less than under normal conditions of living. I am informed by the Aetna Life Insurance Company that in the early days of accident insurance there was only single

indemnity, but that later traveling men took out extra short-term policies while on the road. The insurance companies finally rearranged their policy to provide double indemnity as mentioned above. As further evidence that the hazard to life is much greater under the conditions mentioned, they advise that great care is being taken in issuing new policies during the present year because of the Panama-Pacific International Exposition, which will cause a great increase in travel.

My object in listing vessels destroyed by fire many years ago was to make the table serve as an historical reference, as I found that a number of people with whom I consulted regarding this matter were interested in these earlier fires. I have included a note to this effect in the revised paper.

The statistics quoted by Mr. Berry from the records of the Steamboat Inspection Service cover only vessels inspected by that bureau, as he has stated, whereas those which I have quoted from the records of the Bureau of Navigation cover all American steamers, and are correct as shown by the following letter:—

"Department of Commerce, Bureau of Navigation.

"Washington, *January 28, 1915.*

"Associated Factory Mutual Fire Insurance Companies,
W. O. Teague, Engineer,
Room 510, 31 Milk Street,
Boston, Mass.

"Sir:

"Referring to your request of the 20th instant, this office advises you that the figures given by you as follows are correct:—

Fiscal year ended June 30.	Number of steam merchant vessels totally destroyed by fire.	Number of lives lost.
1906.....	53	12
1907.....	56	48
1908.....	58	5
1909.....	57	16
1910.....	93	23
Similar data for the years 1911 to 1914 are as follows:—		
1911.....	101	10
1912.....	76	18
1913.....	62	21
1914.....	73	16
Total 1906-1914..	629	169

"Data for years prior to 1906 are not available as statistics of losses of American vessels were not published prior to 1906.

Respectfully,

(Signed) A. J. Tyrer,

Acting Commissioner."

My reference to highly inflammable materials used in the construction of vessels and sometimes forming a part of the contents puts the matter somewhat more strongly than I had intended now that it is called to my attention. I have accordingly replaced the words "highly inflammable" by "combustible," which, I believe, will be more suitable considering the general conditions.

The fact that the passengers and crew remained on the burning Volturno over twenty-four hours and the larger part of them finally escaped, was made possible by the slow spread of the fire, and does not demonstrate that conditions on shipboard as regards hazard to life are better than on land, although they really should be, as people are seldom obliged to remain in a burning building.

Mr. Berry is evidently not fully informed in regard to the progress which is being made in the use of all steel construction, and is incorrect in stating, "* * * it has not been demonstrated that a practical structure of this character can be built at all." The following quotation is from the 1914 Annual Report of the Supervising Inspector General, Steamboat Inspection Service:—

"The Steamboat Inspection Service inspects vessels in order to make travel by water safer * * *. It is believed that the greatest peril which is to be met on board ship is fire and * * *, the Government should require that all excursion steamers be entirely fireproof. It may be claimed by some that it would not be practicable to make excursion steamers absolutely fireproof and yet be commercially successful, but attention is invited to a statement made in the Annual Report of the Supervising Inspector General for the fiscal year ended June 30, 1905. In that report it was stated that the question of the inflammability of the ordinary type of river and excursion steamer is one that should have the fullest consideration of the Department, and that while fire is one of the worst conditions that we have to meet and the most appalling in its results, little or no effort has heretofore been made to design these steamers upon any different plan than those in use for years. It was pointed out that paints, compositions and various other compounds of a so-called fireproof character have been suggested and tried, but none seems to have met the purpose of its design. It pointed out also that at that time there was in the course of construction in one of the prominent shipyards of the country a river steamer nearly 300 feet in length that had been designed with a view to having her as nearly fireproof as utility would permit. In the same report for the succeeding fiscal year it was stated that the construction and operation of a fireproof excursion steamer had proven successful beyond the strongest hopes of those who conceived this type of construction. The Supervising Inspector General therefore renews his recommendations made in the Annual Reports of 1905 and 1906 that Congress enact such legislation that will demand this fireproof construction to be required on all excursion steamers hereafter built or contracted for.

"In the meantime, admitting that we do not have absolute fireproof construction on all excursion steamers now in use, the best precautions that we can take against loss of life

and property is to maintain the very best fire-fighting equipment on these steamers, manned with crews well drilled and competent to fight fire should it break out.

"Until Congress requires fireproof construction of excursion steamers it is believed that the use of the sprinkler system already adopted by many passenger steamers should be extended."

With reference to the above recommendation that sprinklers be provided on excursion steamers of non-fireproof construction, this procedure would of course be a great step in advance, but experience on land has shown the necessity for sprinklers even in so-called fireproof buildings, the contents of which are of a more or less combustible nature. I accordingly am of the opinion that sprinklers should also be installed in steamers of fireproof construction. The latest example demonstrating the necessity for sprinklers under these conditions is the recent burning of the Thomas A. Edison Factory, West Orange, N. J., December 9, 1914, which involved a loss of several million dollars, largely because of the complete burning of the contents and injury to reinforced concrete buildings.

I have recommended that vessels be constructed of steel and other non-combustible material and that the proper fire-extinguishing apparatus, particularly automatic sprinklers, be provided, under which conditions steel will prove efficient as a fire retardant. The use of so combustible a material as wood, even if metal covered, is not advisable.

My paper is intended to apply principally to passenger steamers, and I have recommended automatic sprinklers wherever practicable, which means throughout the vessel except possibly in the cargo spaces where some other means of extinguishment, such as gases, may be more effective. Certainly there is no more danger of sprinklers being broken open in the passengers' and crew's quarters than in buildings where the water damage from this cause is so small that insurance companies insure against water damage from the sprinkler system without additional cost.

In case of collision, water may be discharged from broken sanitary service pipes extending throughout passengers' and crew's quarters as well as fire service pipes supplying hose streams, and while the sprinkler system would add another possible means of discharge, it should not increase the danger of panic materially.

I agree that if a constant water pressure could be maintained continuously by the steam pump, there would be but little necessity for other sources of water supply such as a gravity or pressure tank, but long experience on land has shown that pumps can not be depended upon to continue in constant service without repairs, and that they sometimes fail at time of fire. The most recent instance of this occurred during the Salem conflagration, June 25, 1914, when one of the two steam fire pumps at the Naumkeag Steam Cotton Co. broke down at the height of the fire in the tenement district adjoining, and although only twenty minutes were required to make repairs, the fire got into the mill buildings, and a good fire-fighting pressure could not again be raised. While of course I can not say that the mill would have been saved if this accident had not occurred, it undoubtedly hastened the complete destruction of the property, resulting in a direct loss of $3,500,000. A tank supply would have maintained pressure automatically during these critical moments.

Furthermore, engineers, with whom I have advised, agree that the installation of a gravity tank on shipboard is entirely practicable. To secure the best pressure the tank should of course be placed above the highest portions of the vessel provided with sprinklers, and although this would have some detrimental effect on the stability of the vessel, it would be

negligible as far as the larger ones are concerned, and this disadvantage would be greatly offset by the great increase in the efficiency of the fire protective equipment.

With reference to remarks by Mr. Forbes, I am surprised that he is satisfied with the partial protection afforded by the perforated system which was abandoned many years ago on land, especially since such excellent protection is available by the use of the automatic sprinkler system.

I do not agree with him that "A dry-pipe system is of very little value in shore work, under most conditions." The fact is that this system has proven to be quite reliable, and is used to a very large extent to-day where the heating of buildings is expensive or undesirable. It should also prove satisfactory on vessels, provided an approved type of dry-pipe valve is used and the system is properly installed and maintained.

Mr. Stevenson Taylor, *Past President* (Communicated):—My attention has been especially called to the figures of loss of life by fire on the "Merchant Vessels of the United States" for the years 1906–1910, inclusive, originally given by Mr. McComb in his paper at our 1910 meeting, and which are now repeated by Mr. W. O. Teague, who has added similar figures for the years 1911–1914, inclusive. Mr. Teague gives as his authority a letter from Mr. A. J. Tyrer, Acting Commissioner of Navigation, Washington, D. C.

The Bureau of Navigation, according to section 10, law of June 20, 1874, receives reports of every accident on all of the vessels of the United States.

These reports include not only every vessel duly licensed by the Steamboat-Inspection Service, but also all sailing vessels, barges, and other boats that do not come under the laws governing the inspection of steam vessels.

The Steamboat-Inspection Service is the Bureau of the Department of Commerce that by law covers all apparatus for the protection of life on vessels carrying passengers for hire, and the records of this Service are the only ones that should be quoted as arguments in papers like Mr. Teague's.

To show the difference between the figures in the table given by Mr. Teague and the figures compiled from the annual reports of the Supervising Inspector-General of the Steamboat-Inspection Service it is not necessary to go farther back than 1912. The records in either case for the fiscal years ending June 30, 1912, 1913, and 1914 are fair examples of all of the years quoted by Mr. Teague, who gives for these particular years 211 vessels totally destroyed by fire with a loss of 55 lives, while his same authority, Mr. Tyrer, Acting Commissioner of Navigation, reports, in reply to my inquiry, a total of only 14 vessels burned resulting in the loss of life, with a record of 59 lives lost, but this record includes four vessels really destroyed by explosions which caused a loss of 30 lives and Mr. Teague cannot claim that any suggestion of his would have made any difference in these cases. Some of the vessels noted did not come under the Inspection Service.

The following table for the same years will show the actual facts as to fires on duly inspected vessels resulting in a loss of life as well as other interesting particulars:—

Fiscal year ending June 30.	Number of fires on vessels resulting in loss of life.	Number of lives of crew lost.	Number of lives of *passengers* lost.	Total lives lost.	Total number of accidents of all kinds resulting in loss of life.	Total number of lives lost.	Deduct lives lost by causes not coming under inspection. See note.	Net number of lives lost, including crews See note.	Number of passengers carried.	Number of lives lost in City of New York at fires.
1912....	3	4	**0**	4	39	264	80	184	307,692,494	65
1913....	4	6	**2**	8	66	436	216	220	303,263,033	72
1914....	4	9	**1**	10	232	582	185	397	318,094,347	85
Totals	11	19	**3**	22	337	1282	481	801	929,049,874	222

Note. The 481 lives lost mentioned here were from accidental drowning, suicide and other miscellaneous causes for which inspection, condition or construction cannot be held accountable.

From this table it will be seen that the number of lives lost by fire on vessels in 1912, 1913, and 1914, was one for 42,229,540 passengers carried.

The number of lives lost by causes coming under inspection, including fire, one for 1,159,863 passengers carried.

The number of *passengers'* lives lost by fire in 1912, 1913, and 1914, *one* for every *309,683,291* passengers carried; and these numbers do not include the millions of passengers carried on vessels like ferryboats which are not required by law to report same.

Of the eleven vessels upon which there were fires resulting in loss of life during 1912, 1913, and 1914, there were *six under 100 feet long and five between 112 and 165 feet long.*

It will therefore be seen that the figures of Mr. Teague's table are misleading when given with his subject "Safety of Life from Fire at Sea."

Mr. Teague commences his paper with "Safety first!" Well, taking the same nine years, 1906–1914, inclusive, mentioned by him, we find from the records of the Steamboat-Inspection Service covering all vessels propelled in whole or in part, all gasoline and other boats carrying passengers for hire and all freight and towboats (*vide* Revised Statutes, Sections 4399, 4426, and 4427) there were from fire, collisions, explosions, wrecks, foundering in severe storms and sinking, a total of 2,312 lives lost on all of the classes of vessels before mentioned; and there were carried during the same period 2,983 millions of passengers. That is to say, one life was lost of crews and passengers for every 1,290,000 passengers carried. Where in the world were so many people carried with such small loss? What other form of public service can show comparable results?

It is not impossible that this marvelous record may be changed, but let us do the owners, operators and inspectors of our vessels the justice of giving them full credit for their present record, which certainly gives no reason for causing their passengers unnecessary alarm.

As has been truly said before, traveling on the streets of our large cities is more dangerous than traveling on our steamers.

Mr. Teague (Communicated):—The communicated discussion by Mr. Stevenson Taylor gives valuable data as to the loss of life from fire at sea, accurate statistics being

difficult to obtain, as I stated in my paper. It is evident that Mr. Taylor has put a good deal of time and effort into this investigation and I greatly appreciate his kind assistance. While I have not been able to check his figures I have no doubt but that they are correct and that they should be considered a proper basis to form an opinion on this subject.

Mr. Taylor admits, however, the possibility of an appreciable increase in loss of life at any moment, which is the most important point I have endeavored to bring out in my paper. The recent burning of the passenger steamer Parisien at sea, which fortunately did not result in loss of life, shows the ever-present danger, which should be more thoroughly guarded against.

THE CHAIRMAN:—I tender the thanks of the Society to Mr. Teague for his interest shown in the Society by the presentation of this paper, and I trust that the discussion produced by it may contain some questions of interest to you.

Paper No. 4, "Launching Data for a Battleship," will be postponed until the afternoon session, as it is to be illustrated by some lantern slides which have not yet arrived.

It is now getting late, and we will adjourn for luncheon. The Council will kindly meet immediately after the meeting has adjourned.

SECOND SESSION.

THURSDAY AFTERNOON, DECEMBER 10, 1914.

Rear Admiral Washington L. Capps, acting as Chairman, called the meeting to order at 2.15 o'clock.

THE CHAIRMAN:—The paper which was to have been the first of the afternoon session requires the use of some lantern slides which have not yet arrived, so that the first paper to be presented at this session will be No. 6, "The Expansion or Contraction of Dimensions and the Effect upon Resistance," by Prof. Herbert C. Sadler. Paper No. 6 will be followed by No. 7.

Professor Sadler presented his paper.

THE EXPANSION OR CONTRACTION OF DIMENSIONS AND THE EFFECT UPON RESISTANCE.

By Professor Herbert C. Sadler, Member of Council.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

In the preparation of the plans for a new vessel it frequently happens that the designer has at hand the trial data as to speed and power for a vessel, similar, so far as the coefficients of form are concerned, but whose ratios of dimensions are not the same as those of the proposed vessel.

From former experience and results of model tests already published, it may be possible to estimate the effect of change in ratios of dimensions with a fair degree of accuracy, but in order to obtain additional data upon this subject and to bring the results into a more concrete form the following investigations were undertaken:

Three different types of ordinary mercantile forms were designed ranging in longitudinal coefficients at the deepest draught from .551 to .674. Each model was tested at three different draughts, but the same actual draughts were used in each case.

A number of models of each type were made of varying breadths, by simply expanding or contracting the parent form in this direction only, the length and draught in each case remaining constant.

In a similar manner the length and breadth were held constant and the under-water form changed by varying the distance between the original waterlines only, *i. e.*, expanding or contracting the draught. Also, the breadth and draught were kept constant and a series of models made by expanding or contracting the distance betwen the transverse stations, *i. e.*, expanding or contracting the length.

Finally, the three forms were tried of the same displacement, breadth and draught, but of different lengths and hence different coefficients of form.

The coefficient of midship section was kept constant throughout the series.

In all of the foregoing, therefore, the displacement for each type was allowed to vary in the same ratio as the variation of the particular dimension.

The particulars of the three types are given in the following table:

Draught.	Type 1.			Type 2.			Type 3.		
	C_m	C_l	C_b	C_m	C_l	C_b	C_m	C_l	C_b
a	.936	.674	.63	.936	.606	.567	.936	.551	.515
b	.92	.665	.612	.92	.598	.537	.92	.544	.501
c	.904	.648	.585	.904	.583	.526	.904	.530	.479

The varying ratios of length and breadth and draught are shown on the respective curves.

The curves of sectional areas of the parent forms are shown on Plate 8, and represent the three different types of varying length and constant displacement. In presenting the results of the experiments it has been deemed advisable to give them in the form of wave-making resistance per ton of displacement, in terms of speed-length ratio. For any particular case the surface friction is readily calculated, and although when total resistance is considered the results may appear different from those due to wave resistance only, it is the latter which is usually the unknown quantity. The fact that the residuary resistance is obtained by subtracting the frictional from the total resistance, together with possible minor experimental errors, would probably account for certain inconsistences which appeared in the final results. In general, however, within the limits of economical speed for each type, or before the region of the first "hump" in the resistance curve, the results were fairly consistent, and the following curves represent the average variation in each case. Beyond the above speeds the variation in resistance did not seem to follow any simple law but varied somewhat with the speed.

The curves shown in Plate 9 represent in general the variation of residuary resistance per ton of displacement with respect to breadth. They are the results for the medium draught (*b*) for each type, but the same characteristics were found to hold for the other draughts at which the models were tried.

Within the limits of the variation of breadth shown, the residuary resistance appears to vary as about the 1.65 to the 1.7 power of the breadth, or the residuary resistance per ton of displacement as about the .65 to .70 power of the breadth, if the lines are simply expanded or contracted and the displacement allowed to vary accordingly.

The effect of variation of draught due to expanding or contracting the dimension in this direction, did not appear to be quite as consistent as in the previous case, but in general the average results are shown in Plate 10. They are for the forms represented by the medium draught (*b*). Up to the limit of economical speed the residuary resistance varies as about the .65 to .7 power of the draught. Above these speeds the index gradually increases. The residuary resistance per ton of displacement therefore varies inversely as about the .35 to the .3 power of the draught.

If length alone is varied, breadth and draught being kept constant, we have simply a combination of the foregoing: for if all dimensions were varied proportionately the residuary resistance per ton of displacement would be constant at constant speed-length ratios. Increasing, say, the length only is therefore equivalent to reducing both breadth and draught of the parent form simultaneously.

As a check upon this, each of the forms was expanded or contracted longitudinally, and the results are shown for the medium draught (*b*) in Plate 11. If the length be increased, say, n times, breadth and draught remaining constant, we obtain a similar form to that of the parent type in which the breadth and draught have each been reduced n times; and therefore if the residuary resistance per ton of displacement at corresponding speeds varies as the .7 power of the beam and inversely as the .3 power of the draught, the combined result would be that this factor will vary as $n^{.3} \div n^{.7}$ or $\frac{1}{n^{.4}}$. In other words, the residuary resistance per ton at constant speed-length ratio will vary approximately inversely as the $(\text{length})^{.4}$. An examination of the above curves, Plate 11, will show that this is practically the case.

As the three original parent forms were made of the same displacement but of different lengths, the effect of influence of length for this particular series could be readily obtained. The curves, Plate 12, show the results for the three different draughts at which the models were tried. They represent constant speed curves for varying lengths with constant beam, draught and displacement, and illustrate the well-known influence of length as affecting residuary resistance. The total resistance curves would not, of course, show such a marked difference, as the longer form, though finer, would have a greater friction than the shorter and fuller form.

SHALLOW-DRAUGHT TYPES.

In connection with some experiments upon certain types of river steamers, such as those of the Mississippi stern-wheel type, occasion was had to determine the effect of variation of breadth only. These are rather extreme types where the ratio of length to draught was from 40 to 50 and the ratio of breadth to draught varied from about 8 to 12. Two different types were tried, the stern in both cases being that usually adopted for the stern-wheel vessel, and the bows either ship-shape or "scow" form.

In these cases the wave-making resistance at corresponding speeds, within the limits of speed at which these vessels would normally be run, appears to vary as about the .75 power of the beam, or per ton of displacement inversely as the .25 power of the beam.

As the models of the above contained a large percentage of parallel middle body, this part, which represents a practically rectangular form, was also tried at different breadths. The ratio of breadth to draught was the same as for the previous forms, but in this case the residuary resistance appeared to vary directly

as the beam, or the residuary resistance per ton of displacement was constant at corresponding speeds.

In conclusion, a word of caution should be given about extending the above results beyond the limits of the experiments, both with regard to dimensions and speed. Within these limits of, say, 20 per cent variation no serious error will be involved if the residuary resistance per ton of displacement at constant speed-length ratios be assumed to vary as about the .7 power of the breadth, inversely as the .3 power of the draught, and inversely as the .4 power of the length; or the residuary resistance be assumed to vary as the 1.7 power of the breadth and as the .7 power of the draught, and .6 power of the length, for similar normal mercantile types at corresponding speeds.

The results also emphasize the fact that the draught is the more economical dimension to increase, if increased displacement of a given type is desired.

For very wide and shallow forms, however, the influence of breadth upon residuary resistance does not appear to be as marked as in the case of the more normal forms.

THE CHAIRMAN:—In the unavoidable absence of the author, which, I am sure, we all greatly regret, Professor Sadler will read paper No. 7, "Some Experiments with Models Having Radical Variations of After Sections," by Naval Constructor D. W. Taylor, U. S. N.

Professor Sadler presented the paper.

SOME EXPERIMENTS WITH MODELS HAVING RADICAL VARIATIONS OF AFTER SECTIONS.

By Naval Constructor D. W. Taylor, U. S. N., Vice-President.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

When we determine the form of a ship there are two things which must be done in connection with every station or section. We must, by some means, fix the area and then determine the form or shape to be given the section having the given area. Taking ships as they are, for given dimensions and displacement there is not room for very large optional variations of sectional area except near the extremities. The designer has a fairly free hand, however, when it comes to the shapes of the sections, particularly toward the extremities.

There are, of course, matters to be considered in connection with these shapes other than the question of resistance, such as seaworthiness, carrying capacity, etc., but it should be understood that in this paper questions of resistance only are taken up. Broadly speaking, as regards the shape of sections, the accepted practice is to approach the U-type forward and the V-type aft. From our experience at the U. S. Model Basin this practice, as regards resistance, would appear fully justified as to the bow, the U-type of section being nearly always desirable forward. Moreover, the resistance seems to be more affected by changes forward than by the changes aft, or, to put it in another way, to depend more upon the forward form than upon the after form.

Systematic variations of form of entrance generally result in systematically varying resistance and allow definite conclusions to be drawn. When it comes to the run, however, we find it much harder to draw definite conclusions. Changes in the form of the after sections appear to affect the resistance less than do changes forward, and changes of resistance for systematic changes of after form are not always systematic. So, while we feel that the standard practice is probably right and that V-sections aft are desirable from the point of view of resistance, we do not feel that here we are upon such firm ground as with regard to the U-sections forward.

In view of the difficulty of obtaining definite characteristic results from comparatively small changes of shape aft, we have recently made some experiments with after forms of radically differing shapes, and it is the object of this paper to put before the Society the results obtained. Six after bodies were tested for resistance, all with the same fore body and all having the same curve of sectional areas. All models were 20 feet long in accordance with the standard practice at the U. S. Model Basin. The beam was 1.828 feet; draught, 1.179 feet; displace-

ment, 2,500 pounds in fresh water; midship section coefficient, .98; longitudinal coefficient, .6122; block coefficient, .60.

Fig. 1, Plate 13, shows the original lines, including stern A and the curve of sectional areas for all models. This was one of the models tested last year, the results being included in my paper of last year on "Relative Resistances of Some Models with Block Coefficient Constant and other Coefficients Varied." Sterns B, C, D, E and F are shown in Figs. 2, 3, 4, 5 and 6, Plate 14. Fig. 7, Plate 15, shows the curves of total resistance and the estimated wetted surface resistances, and Fig. 8, Plate 16, shows the residuary resistances.

The underlying idea of stern B was a shape which would start the water up more quickly than in the standard type. The idea of stern C was to carry right aft sections derived from the midship section (98 per cent coefficient), beam only being decreased; in other words, to make a wall-sided model. Stern D was stern C disposed horizontally instead of vertically. The beam was kept constant and draught only was changed, as we went aft, the sections having 98 per cent coefficient. In other words, stern D was an exaggeration of the flat-stern type. Stern E was a combination of sterns C and D, the attempt being made to combine them half and half as it were, and coax the water up along a bilge diagonal. In stern F not only was the coefficient .98 retained for all sections, but they were made geometrically similar to the midship section, beam and draught both being decreased as necessary to obtain the required area. For sterns C, D, and F the sectional coefficient is constant, .98, as already stated.

Fig. 9, Plate 17, shows how this constant sectional coefficient contrasts with the curves of sectional coefficient of A, B, and E. It is typical of V-sections that the sectional coefficients are below .5, but when we consider that in the conventional type the after sections include actual or virtual dead wood, it is evident that the numerical value of a sectional coefficient aft has small significance as indicating the nature of the form with which the water has to deal.

The outstanding result of the experiments was the good showing of stern F. Of course this was partly due to small wetted surface, but stern F shows up very well in the curves of residuary resistance, indicating that even with a conventional dead wood added it would still be somewhat the best.

Stern D, the exaggerated flat stern, undoubtedly makes the worst showing in Figs. 7 and 8, Plates 15 and 16, which is at first sight surprising in view of the fact that the wide, flat stern is used with success on many fast boats. But the wide, flat stern as used is usually of type somewhere between D and F, and Figs. 7 and 8, Plates 15 and 16, do not go up to torpedo-boat speed. For 20-foot models torpedo-craft speeds correspond to 8 knots or more, and it is quite possible that at 8 knots stern D would show the least resistance. The models used were not of high-speed type, having four or five times as much displacement for a given length as a high-speed torpedo-boat model, and hence were not tested to high speeds. It is interesting to note that the excessive resistance of stern D at speeds a little below five knots is really due to a characteristic favorable to high speed. The virtual or ef-

fective length of model D is greater than that of the others and, when the curves of the others are past the 4½-knot hump and drop down into the succeeding hollow curve, D is still on the hump.

Other conclusions might be drawn from the curves, but it would not be safe to generalize from a few results. Bearing in mind that a ship of the displacement length coefficient involved would not be powered in practice for speeds above 4 knots, the results appear to indicate that gain could be made at practical speeds by departing from the conventional type of after body, but that they would be comparatively small after all. They would be of the 5 per cent order, not 15 or 20 per cent.

DISCUSSION.

THE CHAIRMAN:—Gentlemen, these two papers are very brief, but they represent a good deal of research and contain very interesting data. Discussion is now in order.

PROFESSOR HERBERT C. SADLER, *Member of Council:*—In connection with Naval Constructor Taylor's paper I may say that it confirms in every respect some experiments that I conducted some years ago in connection with barge forms. They were somewhat more simple forms even than those of Mr. Taylor, having square corners. We found that the form such as shown in the stern F was, on the whole, the best for ordinary working conditions, and provided that we got the correct angle of the line through the bilge, that that form had very little more resistance than the best ship shape form.

With regard to the other forms, the stern C, which is a straight-sided vessel, we found that it was decidedly bad under ordinary conditions of depth of water, but in shallow water that type of stern, and bow as a matter of fact also, seemed to show up slightly better than some others. In this connection it is interesting to note that in very shallow water the flow would only take place in two directions, and consequently a form that is easy in those directions only, viz., length and breadth, will probably give the form of least resistance; but when you come to deeper water, where the water wants to flow in a diagonal direction, then a form such as shown in stern C is decidedly bad. The same thing applies in a lesser degree to stern D—the ordinary scow-shaped stern—the water does not want to follow in exactly fore-and-aft lines; evidently it wants to come in from the side, from part of the hull, and come up from the bottom from the other part, and consequently the stern D will give slightly more resistance than a stern such as F, which is a compromise between the two.

With regard to the stern E, that is interesting as illustrating the fact that it is quite possible to make a stern too fine, that is, particularly toward the extreme ends. Evidently in that case the water does not want to flow up on quite such a fine bilge diagonal as shown there, and a fuller form of bilge diagonal will give a more natural flow line and consequently less resistance.

I think from an analysis of some of these simple forms we can get, perhaps, even more

valuable information than from a series of experiments on the ordinary ship shape form, because they do indicate in a very clear manner the way in which the water seeks to flow around a ship's hull.

THE CHAIRMAN:—Is there any further discussion?

PROFESSOR WILLIAM HOVGAARD, *Member:*—The influence upon resistance of expansion or contraction along the principal dimensions has been studied experimentally by R. E. Froude, by Naval Constructor D. W. Taylor, and by Col. G. Rota. These experiments I have analyzed, and the result was published in the Transactions of the Institution of Naval Architects in London in 1908. I found that the residuary resistance for ships of the cruiser type varied as the square of the beam and as the draught to the first power for speed-length ratios not greater than 1.35. I had not then at my disposal any serial experiments on the expansion of the transverse dimensions in ships of full form such as those experimented on by Professor Sadler.

For changes in length-scale of cruiser models, I found that the residuary resistance was constant at corresponding speeds for speed-length ratios up to unity, but for models of the Connecticut type a discrepancy in this law appeared at speed-length ratios exceeding about .75.

I arrived at the following empirical expression for the residuary resistance:

$$R = b\frac{B^2 D}{L^2}V^4$$

where b is a coefficient that varies with the cylindrical coefficient of fineness. This may be written:

$$R = B^2 D^1 L^0 \left(\frac{V}{\sqrt{L}}\right)^4$$

which appears to hold good for vessels of the warship type up to the point where interference between the bow and stern waves begins to be sensibly felt.

I am much interested in the results obtained by Professor Sadler, according to which the resistance for ships of ordinary mercantile form at corresponding speeds varies as $B^{1.7} D^{.7} L^{.6}$ as against $B^2 D^1 L^0$ for warships. The discrepancy between these results and those of earlier experimenters must be due to the great difference in the type of the models. Possibly the wave interference is felt earlier in Professor Sadler's model, and may have obscured the true law of variation, which might still be that obtained for finer vessels. The analysis of the results obtained with the Connecticut model points in that direction. It would be interesting to have Professor Sadler's opinion on this point.

PROFESSOR SADLER:—In reply to Professor Hovgaard, I would state that, being aware of his deductions from former experiments, I was a little surprised to find the factors for variations of dimensions come out in the manner given in the paper. The difference is probably due to the difference in type of vessel; in the one case you have a somewhat high rise of flow, easy bilge, fine lines and cruiser stern, and in the other a flat bottom, sharp bilge, flat sides and counter stern. In no case, however, in the above experiments, did the residuary resistance appear to vary as so high a power as the square of the breadth.

THE CHAIRMAN:—Is there any further discussion? Papers of this character are largely records of research and, while most illuminating, they do not lend themselves freely to discussion. They require, in fact, much more careful consideration than members usually have time to give to them before their presentation.

I feel sure, however, that you will be glad to extend your thanks to Professor Sadler and to Naval Constructor Taylor for preparing and bringing these papers to your attention. I also feel sure that I only voice your sentiments when I say that it is a matter of especial regret that Naval Constructor Taylor is not with us in order that he might receive, as he undoubtedly would, our felicitations upon his prospective advancement to the head of one of the most important branches of the public service. His past professional career leaves no doubt whatever that the work he will soon undertake will be carried out with the best possible results for the country and with the greatest credit to himself.

CHIEF CONSTRUCTOR TAYLOR (Communicated):—My little paper was intended to be more in the nature of a preliminary report than a record of a complete investigation. I was very glad to learn that Professor Sadler's experiments agree with our results. We think that if we can, from a single type of section for the stern sections, obtain results agreeing with those from models having the ordinary type of section, we may be able to investigate the influence of variations in the curve of sectional area upon resistance without introducing complications due to the shape of sections. This is very desirable, as we thereby are enabled to investigate one variable at a time. The matter is being given further investigation in the Model Basin, and I hope at some future date the results may be laid before the Society.

The Chairman's very kind and very much appreciated remarks upon my change of duty impel me to say that the papers giving results of investigations at the U. S. Model Basin, which it has been a privilege and a great pleasure for me to present to the Society for so many years past, will hereafter be presented by others; but if the Secretary continues to insist upon so many Model Basin papers in the future, I shall certainly use my influence with the authorities in charge to induce them to continue the supply.

THE CHAIRMAN:—The lantern slides which will accompany Paper No. 4 have not yet arrived, and we will take up No. 5, entitled "Stability of Vessels as Affected by Damage due to Collision," by Mr. William Gatewood. In the absence of Mr. Gatewood, Naval Constructor Linnard has consented to read the paper for him.

Mr. Linnard read the paper.

STABILITY OF VESSELS AS AFFECTED BY DAMAGE DUE TO COLLISION.

By William Gatewood, Esq., Member.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

Stability is a subject which should receive consideration before the dimensions of a vessel are settled. The height above base line of the initial metacenter can be determined, with a fair degree of accuracy, by the use of coefficients. A convenient formula is—

$$\text{Metacenter above base} = aH + c\frac{B^2}{H}$$

In this formula H represents the draught and B the beam of the vessel; aH is the height of the center of buoyancy above base and $c\frac{B^2}{H}$ is the height of the metacenter above the center of buoyancy. For coastwise passenger and freight steamers of modern design having fine load waterline forward and full midship section, the coefficient a will vary between .57 and .54, depending on coefficient of fineness and exact shape of lines, and decreasing for the same vessel about .01 as the draught increases from 12 feet to 24 feet. For the same type of vessel, the coefficient c will vary between .078 and .082, depending on the exact shape of the load waterline and the fineness of the vessel. For the older vessels, with considerable deadrise and with V-shaped lines forward, both coefficients will be found to be greater. If they had not taught that increase in beam does not, *ipso facto,* imply increased resistance to motion, the model tanks could be blamed for a reduction in metacentric height on passenger steamers, because they are responsible for small deadrise and for fine load waterlines forward on vessels which are designed to obtain a good speed on small horse-power.

The determination of the height of the center of gravity above base cannot be approximated so readily. The vessel, as completed and loaded, can be considered as composed of six items:—

1. The hull and fittings below the highest continuous deck.
2. The hull and fittings above the highest continuous deck.
3. The machinery.
4. The fuel and water.
5. The passengers, crew and stores.
6. The cargo.

In the preliminary stages of the design, an approximation of the weight and vertical center of gravity of each of these items may be made, and the results combined, in order to get an approximate figure for the height of the center of gravity of the loaded vessel. An inclining experiment made on the vessel when completed will serve to eliminate uncertainty as to some of the items, generally the first three. The last three items are variable quantities, and must be figured, at best. It has been proposed to determine the metacentric height of vessels before each voyage by inclining them as soon as the cargo is on board. Experience in inclining vessels at a shipyard indicates that the results would not be likely to be reliable, as the readings are affected so greatly by loose water and moving people. Greater accuracy is likely to be obtained by determining beforehand how much weight of cargo is to be stowed in each division of the vessel in order that the center of gravity of the cargo may not exceed a certain height above base, considered desirable in order to obtain a predetermined minimum metacentric height under the most unfavorable conditions of bunkers likely to occur on the voyage.

This leads up to the question: What is the minimum metacentric height for any vessel consistent with safety? The question is susceptible of several answers, depending on whether the vessel is considered as intact and exposed to storm and waves, or as "damaged" either in still water, in a moderate sea, or exposed to storms.

In general, it may be stated that passengers prefer a vessel with a long period of roll, as the discomfort is much reduced thereby. To obtain a long period it is necessary to have a large vessel or a small metacentric height; and the combination of the two requisites in the large Atlantic liners renders travel on them a pleasure instead of a bugbear to the landsman with a "sympathetic" stomach. If the small metacentric height is accompanied by a high freeboard and a considerable range of stability, there is small danger of capsizing, due to wind and waves, while "intact." This "comfortable" condition of a vessel, however, may be a source of great danger even in still water if the vessel is damaged by collision.

To illustrate the conditions obtaining, a coastwise passenger steamer 370 feet long, 49 feet 6 inches beam, and 35 feet deep to hurricane deck, has been selected. The vessel is considered as subdivided in accordance with the regulations proposed by the International Convention on Safety of Life at Sea of 1913–14, as a vessel engaged in a mixed cargo and passenger service. The load draught allowed with bulkheads extending to the main deck (the lowest point of which is 26.92 feet above base) and with machinery compartment 65 feet in length, is 21.7 feet. At this draught it is assumed that the cargo is so loaded that the metacentric height is 6 inches. The range of stability, as shown on Fig. 1, Plate 18, figures out at 82 degrees, and the maximum righting arm is 1.9 feet at 48 degrees inclination. It would be a pleasure to sail on this vessel under such conditions.

Now let us suppose that the machinery compartment is opened to the sea by collision, that the permeability of this compartment is .80, that the water surface in the damaged compartment at all stages has an inertia coefficient of .80, and that

the water has free access across the compartment. As the compartment fills, the center of gravity of the vessel and contained water would fall as indicated by the line marked "Locus of center of gravity" in Fig. 2, Plate 19. The center of buoyancy would rise as indicated by the line marked "Locus of center of buoyancy." The metacenter would fall as indicated by the line marked "Locus of metacenter."

A condition of unstable equilibrium is indicated almost as soon as the water begins to enter the vessel. If the vessel remained upright so that the center of gravity of the entering water would be on the center line of the vessel, this condition of instability would continue only until the compartment was one-third full and a draught of 23.1 feet was attained. The metacentric height would rapidly increase as additional water entered, and would become as much as 1.1 feet at 25.9 feet draught, when the water would cease to flow in, having attained its level. The freeboard to main deck in this condition would be about 12 inches, and there would appear no reason why the vessel should not stay afloat in a perfectly calm sea, although the margin of safety as regards freeboard would seem insufficient except under ideal conditions of sea and weather.

But the combination of unstable equilibrium and the inflow of water from one side would surely cause the vessel to list toward the damaged side. This list would continue to increase even after there was a positive metacentric height indicated by the diagram, owing to the fact that the center of gravity of the flooding water would lie toward the low side, as obstructions would prevent a rapid flow across the compartment. Fig. 1 shows that the list caused by the negative *GM* would cause the main deck at the side to be submerged. When the main deck at the side is submerged, the water will flow forward and aft along the deck and flood the adjacent compartments, as well as further lower the metacenter. The list will continue to increase, and the vessel will settle deeper in the water and finally sink. The time elapsing from moment of damage to complete submergence would depend on a number of circumstances, but recent collisions have shown that not over fifteen minutes is sufficient.

After complete submergence, there would be a righting moment due to the fact that the materials of the houses, etc., would be of less density than the material of the main hull. The cargo might be of such varying density as to give a righting moment also. It is probable, therefore, that as the submerged vessel rests on the bottom she would approach a vertical position with masts upright, or nearly so.

From Fig. 3, Plate 20, it will be noted that the conditions are not far different when No. 2 hold, 76 feet in length, is flooded. Permeability is taken at 64 per cent.

It would appear, then, that in order to prevent this vessel from overturning when one compartment is open to the sea by collision, it is necessary that the initial metacentric height should be sufficient to prevent a condition of instability in any stage of the flooding. For the particular vessel which has been investigated, the initial metacentric height must exceed 1.4 feet by a margin sufficient to allow for the upsetting moment caused by the fact that in the process of flooding an excess of water will be on the damaged side.

If this vessel has an initial metacentric height of say 2 feet, and is subdivided in accordance with the rules of the International Convention, and when at the draught allowed by those rules is injured in a collision, with the consequent flooding of the machinery space or of an adjacent hold, the danger of overturning would seem to be eliminated, provided the sea is smooth. But if the permeabilities established by the conference represent average practice, the freeboard to the top of the bulkheads will be only about 12 inches. It would appear that, if the cut in the side is of any size, a very moderate sea would serve to send the water forward and aft of the damaged compartment, over the tops of the bulkheads.

The results of this investigation would seem to show two things:—

First, for a coastwise passenger and freight vessel of the hurricane deck type, subdivided in accordance with the rules of the International Convention as a Class B vessel, and having a machinery space or holds of about one-fifth the length of the vessel, an initial metacentric height of not less than 18 inches should be an important element of the design.

Second, greater safety would be obtained by extending the bulkheads to the hurricane deck, or by otherwise preventing the flow of water fore and aft on the main deck.

DISCUSSION.

The Chairman:—This interesting paper is now before you for discussion.

Naval Constructor Joseph H. Linnard, *Member of Council:*—My personal impression, from reading the various proceedings and published papers with respect to the action of the Committee in London, was that these matters had been taken into consideration to the extent that it was deemed feasible. In establishing general rules it is, of course, impossible to figure out detailed cases; such detailed cases are to be dealt with by the respective governments in the way they deem proper to produce the results. I think it has been remarked that, as a matter of fact, although there are a great many vessels with very small initial metacentric height, yet it is rare that merchant ships when damaged turn turtle before they go down. I do not have in mind any such case in these disasters that have been recently noted in the press. Perhaps Admiral Capps, having been on the Commission, will be able to tell us more in detail the considerations that governed the Commission in these matters.

Mr. John Reid, *Member:*—It is many years now since this question of stability came to be considered one of the most important in the design of any ship, but it is certainly curious to find that there are so many ships now sailing, and some even building, in which the stability is so far at fault. If it were not invidious to mention names, I could give you in my experience the names of three or four large Atlantic liners, very popular ships, very

comfortable, now on the Atlantic, in which the stability leaves a great deal to be desired; and without mentioning names I am sure that many of you are now aware that there is in this country a large passenger boat now in dock, a vessel which originally cost over half a million dollars, and considerable more, and intended to carry hundreds of passengers, a brand new ship, which is now being cut up and widened by two feet on each side—at least, that is what I heard—in order to get the stability into shape. That brings up this consideration: How does it come that a ship of that importance, on which so many people are going to be voyaging and risking their lives, can be built by a first-class firm and then have to be radically reconstructed in order to get the stability put right? My impression is that the naval architect is not getting his share in the design that he ought to have. We are all aware that between the shipowner and the shipbuilder there is always a friendly antagonism—sometimes not so friendly. The shipowner wants to get the most out of a given expenditure for a given sized ship, and the shipbuilder wants to get the most satisfactory result without putting any more money into the construction of the ship than the price at which he contracted to build it. It is remarkable, when you look at the present Atlantic liners of the latest type, to see the enormous height of the superstructure, the living rooms, the smoke rooms, etc., which have offset, and very often more than offset, the advantages gained by great beam in proportion to the length of the ship. When you are voyaging in one of these very large vessels in every kind of comfort and suddenly, as has happened in my own experience and without any warning, but due to some minor condition, the vessel takes a very heavy lurch and lies right down and stops there for several hours, you begin to realize that, in the antagonism between the shipbuilder and the shipowner, the shipowner has probably come out best, so far as the accommodations and superstructure are concerned. I do not want to elaborate on that, but I am sure you are all familiar with some of these conditions.

This paper by Mr. Gatewood deals with a proposed ship which he assumes to have been bilged in one compartment, and then he prognosticates what would happen. It is a very remarkable thing, and I think it shows Mr. Gatewood's ability in a remarkable way in this matter, if you put alongside this comparatively small ship the actual facts in the loss of the Empress of Ireland on the St. Lawrence River this year—if you do that you will find that you can run a parallel right through the two cases. I was called upon this summer to investigate that catastrophe in connection with the inquiry at Quebec, and if you will give me a minute or two I will mention a few facts connected with it, partly because there is a good deal of misconception as to what actually occurred on that ship, and partly because it deals with several matters connected with safety of life at sea, to which I think emphasis has not yet sufficiently been given.

It is considered by a number of people, and published in the press, that the Empress of Ireland was struck by the collier Storstad a glancing blow, with high speed on the part of the Storstad. Now what happened and what was demonstrated and proved by the court was this: That the Storstad struck the Empress of Ireland a blow which did not glance at all; that the speed of the Storstad was comparatively slow, probably not more than four or five knots; and that the Empress of Ireland was also in motion, contributing somewhat to the force of the blow, and that no bulkheads on the Empress of Ireland were destroyed. There is a difference of opinion about that, but I think I am right in saying that it could be easily shown that the Storstad did not destroy any of the bulkheads of the Empress of Ireland. What it did was to cut a hole about 8 to 10 feet wide right from the bilge of the

Empress of Ireland up to the shelter deck, letting water in on to the lower and main decks, and subsequently on to the upper and shelter decks. That hole pierced the after stokeholds. In that stokehold there was a bunker wall. That, of course, trapped the water, and from the moment of the impact the Empress began to heel. The stability of the Empress is undisputed—it was more than the average. I understand that the metacentric height was about 42 inches in its loaded condition at that time. There was no question of the stability or the structural strength of the vessel. There were no bulkheads destroyed, and therefore, as the Empress was designed and built to float with two compartments bilged, there should have been no doubt of her ability to stand up under the blow. What happened was that in the divisional bulkhead between the stokeholds there were watertight doors, which were not shut. We have heard of the lack of permeability of spaces filled with coal and other cargo. It was very extraordinary, the rapidity with which the water came in through the break and permeated the bunkers filled more or less with coal. As the water came over the lower deck it went through the bulkhead doors, from one stokehold into the other, down through the deck escape hatches into the lower bunker, and out through the bunker door on the stokehold floor in five seconds. A man in the forward stokehold found water coming out on the platform almost immediately after the impact. To make a long story short, this longitudinal bunker wall prevented the water from going across the ship and the Empress heeled from the moment of impact, and went over in twelve minutes—absolutely capsized.

Mr. Linnard stated that very few ships capsize after being bilged, but the case of the Empress of Ireland was an exceptional one. There would have been no loss of life had not the Empress heeled over the moment the impact took place and gone down in such a way that the boats could not be launched, and undoubtedly the horror of the catastrophe was entirely due to the failure of the stability of the ship under these conditions.

Now when we are discussing papers of this kind we are all anxious to assist in any little way we can in improving the safety of ships at sea, and you cannot find in the design of the Empress of Ireland any faults in the structural arrangements or in the calculations; but if you have a series of bulkheads pierced by doors, and these doors are not shut, and cannot be shut—no time to shut them—then, of course, a catastrophe might result from a very small, comparatively small damage. The only way to obviate that is to have the very latest system of bulkhead subdivision and bulkhead doors, and means for closing the doors.

I am positive nothing is to be gained by having anything automatic. We have heard in this meeting today about automatic sprinklers. Lots of people have tried to use automatic stokers and automatic governors and all kinds of automatic things on board ship. They are all right in their way on land, but when you put them into ships, in which the conditions vary from minute to minute, hour to hour, and day to day, nothing will enable you to do away with the importance of eternal vigilance, supervision day by day by the engineers and officers; this is true of all classes of boats, no matter whether it is a motorboat, a catboat, a merchantman, or a belligerent battleship or cruiser in which, whenever anything automatic is installed, when the time comes to use it you find you cannot use it. This question of stability is one to which we should pay more attention in the future at these meetings than we have in the past. I hope this is only a beginning in the matter.

THE CHAIRMAN:—Do you know how low the waterlines were on the doors on the Empress?

MR. REID:—Eight or ten feet below the original waterline.

THE CHAIRMAN:—Were they at the side, so there was a longitudinal bulkhead there?

MR. REID:—There was a corresponding bunker on the other side, and then a bulkhead in the center.

THE CHAIRMAN:—A watertight bulkhead in the center?

MR. REID:—A divisional bulkhead.

THE CHAIRMAN:—Enough to confine the water to one side?

MR. REID:—Yes, and also there was a steam-pipe channel in there that kept the water from going across rapidly. The water tended to flow from one stokehold into the other through the open doors.

THE CHAIRMAN (ADMIRAL CAPPS):—Is there any further discussion? This paper deals with a most interesting subject, one that is literally fundamental in all questions relating to safety at sea. I was particularly interested, not only in the subject of the paper, but in the comments of Mr. Reid with respect to the very sad catastrophe on the St. Lawrence. His statement, based upon the facts deduced at the inquiry, I presume, indicates a state of affairs which explains in great part the ultimate tragic results of this collision. I have always taken a very deep interest in maintaining the watertight integrity of main transverse bulkheads, even to the extent of strongly opposing any openings in such bulkheads so long as you could possibly do without them. There have been numerous catastrophes which have resulted directly from openings in main transverse watertight bulkheads, these openings, at the critical moment, not being closed, although all facilities for closing them were provided. So that, wherever possible, one is led to the inevitable conclusion that the really safe bulkhead is the one without openings and with ample structural strength to resist the unusual pressures resulting from damaged condition of the vessel.

The general question of stability, as suggested by Mr. Linnard, was taken up at the London Conference, but no attempt was made to arrive at detailed and definite conclusions, else we would have been there yet. It was a matter of such intricate technical determination that it is safe to say that no large group of even highly trained professional men could, in any reasonable limit of time, evolve a set of rules which could with any degree of satisfaction be made the basis of specific legal enactment. That was one of the curious features developed in the discussion of this subject. The committee, of which I was a member, was in favor, in the beginning, of trying to develop some general regulations which would at least control the subject and compel the most serious attention thereto on the part of owners. One of the first obstacles we ran against, however, was the rather strong opposition, not of those who owned ships, but of those who designed and built ships, as to the practicability of developing suitable and satisfactory regulations. Incidentally, in the course of the discussion there developed the fact that certain large and well-known passenger vessels, which had important longitudinal subdivisions, which longitudinal subdivisions presumably added very much to the safety of the vessel—in the popular mind, at least—also had instructions given to the officers in charge that, in the event of accident, these longitudinal bulkheads should be practically rendered inoperative by opening the watertight doors—and this, through the fear of producing the very result which, according to the testimony of Mr.

Reid, happened in the case of the Empress of Ireland in the St. Lawrence River. If a large amount of side were opened to the sea, and an intervening longitudinal bulkhead confined the entering water to one side of the vessel, the loss of buoyancy and decrease in transverse stability might easily result in disaster to the vessel.

I mention this matter of stability in connection with the work of the London Conference to show that it was not overlooked; but, in the discussion which ensued on bringing up the question, the practical difficulty of doing anything satisfactory in any reasonable time appeared so great that it was decided that this particular subject must be left to the skill of individual designers. I have no doubt that if designers are not unduly limited by owners, the result will be satisfactory; but, if they are limited by owners in such a way as to impair the integrity of the design under certain conditions of damage, then it does seem to me that a naval architect of the right professional feeling will deliberately decline to have his name associated with such a design, and I feel quite sure that such a stand by eminent professional men would prevent any one interested in taking any chance in such a serious matter.

Mr. Gatewood (Communicated):—The object of the paper was to continue the subject of "Safety at Sea" one step into the region which, for reasons which were explained by the Chairman, the International Conference refrained from entering. It can be seen that any set of regulations which covers completely the requirements of safety in regard to "buoyancy" and "trim" and yet fails to cover the requirements as regards "stability" leaves the matter in a position where the skill of the naval architect and the conscientiousness and knowledge of the manager of the vessel must be called on to supplement the regulations, before safety is enhanced.

In any design of mixed freight and passenger vessel, there is a limit to the amount of freight which can be carried in the 'tween decks consistent with obtaining a margin of stability sufficient to prevent capsizing when one or more compartments are filled. This limit can be determined by the naval architect, under assumptions corresponding to those made by the International Conference in determining the height and spacing of bulkheads.

If a vessel turns on its side before sinking, it is presumably safe to state either that there was not sufficient stability or that the stability was not properly safeguarded. An analysis of the records of collisions, I feel confident, will show a large number of cases where this has occurred. The fact that the Titanic did not turn turtle before sinking, although such a large proportion of one side was open to the sea, should not be used as an argument that precautions as regards stability are unnecessary. Had the damage to the Titanic occurred amidships instead of in the fore body, the loss of stability would probably have proved the cause of a more fearful disaster and of a much larger loss of life.

It is to be hoped that if any legislation is enacted by Congress in accordance with the condition which was attached by it to the acceptance of the report of the International Conference, it will take the form of additional precautions in connection with the safety of the vessel, rather than in connection with the means of leaving the vessel.

The Chairman:—I am sure you will permit the Chair to offer to Mr. Gatewood the thanks of the Society for his admirable paper, and that we regret very much that he was not here to present it in person.

The next paper on the program, No. 9, "The Thermodynamics of the Marine Oil Engine," by Mr. John F. Wentworth, will now be considered.

Mr. Wentworth presented the paper.

THE THERMODYNAMICS OF THE MARINE OIL ENGINE.

By John F. Wentworth, Esq., Visitor.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

This paper is intended to present certain experimental data obtained by the writer as well as to reintroduce certain old and well-established facts in a new garb in order that the oil engine may be looked at from a new viewpoint.

The marine oil engine is discussed because in the marine plant every condition must be considered. The marine plant, in its perfect form, must be capable of running at full load with a maximum of power or of running at partial load with a maximum efficiency; and last, but most essential at times, is the ability to run at extreme slow speeds. The marine oil engine, to meet all conditions and take its place as a perfect prime mover at sea, must be capable of being built in large single units, which means that extreme pressures must be avoided. It is not intended to go into all phases of this problem at length in the text, but rather to state the facts, and in the plates accompanying this paper these facts may be studied more in detail. It is true that the fundamental principles of the oil engine even to-day are not widely known. A glaring example of the general misconception of these general principles is found in the brief description of the Diesel oil engine published in Technical Paper No. 37, issued by the Bureau of Mines, Department of the Interior, on the subject of Heavy Oil as a Fuel for Internal-combustion Engines, 1913. On page 8 of this paper we find this statement:—

"The cycle of the Diesel engine, therefore, is to compress air to 450 or 500 pounds pressure per square inch, thereby generating a temperature of approximately 540° C. Into this highly heated air the fuel is injected during the return or second stroke of the engine, in a finely atomized form, at such a rate as will maintain an approximately constant temperature while burning and in such quantity as will yield the required work for that stroke."

Also:—

"This high elevation of temperature by compression is a necessary part of the improved method of using heat. It also causes the spontaneous ignition of the charge of fuel, although that is not the chief reason for the high compression."

Also, on page 9:—

"In general appearance these engines are like explosion engines, although not built so heavily."

When the writer wrote to the Department of the Interior suggesting corrections in this government publication he was informed that the matter was correct and an authority on thermodynamics (Ennis) was quoted.

Without troubling to specialize on these misstatements we will attempt to show—

First, that, if possible, the extreme high pressure of compression must be reduced.

Second, that to give the greatest possible efficiency under all conditions the proportions of air to fuel must be kept constant regardless of load.

Third, that to get extreme or emergency slow speed the injection of the fuel and the ratio of air to fuel should be varied contrary to the condition for maximum efficiency.

Fourth, that the percentage of the stroke during which the fuel valve is held open should be under the control of the operator in order that injection air losses may be reduced.

Fifth, that by reducing the pressure of compression and at the same time hastening the fuel injection the advantage of the high compression is not materially impaired.

Sixth, that by reducing the pressure of compression it is possible to obtain substantially the same power with the same theoretical efficiency but with an increased mechanical efficiency.

Seventh, that by increasing the temperature of the injection air a saving of practically 10 per cent of the fuel now used may be effected without danger to the plant; and in conclusion we shall ask for a brief consideration of a new type of plant combining fundamentals both new and old.

Let us, then, first consider doing away with the high pressure of compression.

In order best to understand the effect of the high pressure of compression and its relation to the cycle of the engine it is necessary to consider temperature volume diagrams of the oil engine and of other types.

On Plate 21 are shown two typical Diesel cards copied from Diesel catalogues of 1898 and 1913. The only peculiar point in plotting these cards is that the end of the expansion stroke corresponds with 100 per cent volume and the beginning corresponds with the clearance of the engine. Plotted in this way it is possible to read pressure and also percentage volume. Assuming that we begin the compression with air at 14.7 pounds pressure and 60° F., the specific volume will be 13.09, and the specific volume at any other point will be 13.09 times the percentage volume. Thus, from the formula $PV = RT$, the temperature of the charge can be figured with a great degree of accuracy. In this formula—

P is the specific pressure or pounds per square foot.

V is the specific volume or the cubic feet occupied by one pound of gas.

R is a constant (53.22 in English units for air).

T is the absolute temperature or glass reading plus 460° F.

By plotting the two cards shown and figuring a certain number of points the

temperature volume diagrams shown on Plate 21 were drawn in. The results from the Diesel engine are well known. It is of interest to us to know how these results are obtained. The first thing to note is that the temperature rises almost vertically during injection. This not alone proves the absurdity of the contention of the Bureau of Mines and their quoted authority, but comparing the 1898 and the 1913 Diesel cards also shows that the trend of the Diesel engine is to approach the conditions of the normal gas engine.

Owing to the fact that the scale of the spring used to indicate this type of engine is so high, there is some difficulty in drawing in the temperature volume line for compression. Since this is the most important part in our present consideration, one way is shown by which this trouble can to a degree be overcome as indicated in Fig. 1 and Table I of Plate 21. The pressures are scaled from actual cards and the temperatures then calculated. Since the pressures are low, a small error in reading will make a large error in the temperature figure. We know that the temperature rise must be gradual. Consequently, if we plot these first temperatures and draw a smooth curve through the points and then figure back from these temperatures, we can get accurate pressure and temperature lines. Table I is calculated from one of my own cards.

On Plate 22 the temperature curves for several conditions have been figured out and plotted. One fact stands out pre-eminent, namely, that the Diesel engine cycle shows no essential difference in operation from the so-called explosion cycle.

In this connection attention is called to work done by Mr. Dugald Clerk. In an attempt to arrive at some figures on the temperatures at different points of the stroke, Mr. Clerk concluded that in a gas engine the temperature of the charge at the end of the suction stroke would be around 260° F. Mr. Clerk arrived at this conclusion as a result of experimenting with a pyromotor on a special testing or experimental engine. This temperature was the result of mixing with the incoming air some of the products of combustion left in the cylinder at the end of the exhaust stroke, and also of drawing the incoming air into the cylinder over the surfaces of the passages of the heated cylinder head. By assuming a like condition in the Diesel engine and by referring to the temperature volume diagrams on either Plate 21 or Plate 22 the following conclusion can be positively drawn: If the Diesel engine can start with a compression pressure of 500 pounds, the charge igniting at a temperature of around 920° F. (glass reading), then after the engine has been running awhile the temperature at the end of compression must be around 1450° F. (glass reading). If this be so the charge will ignite in any Diesel engine at any time after the pressure has exceeded 120 pounds, provided that the engine has run long enough to become normally warm.

In addition to this proof, more interesting are the cards taken by the writer on his experimental engine. These cards are shown on Plate 25. In this engine it was not possible to vary the amount of air compressed per stroke as much as was desirable. Also the timing of the fuel valve caused slight trouble. As a result the fuel valve was arranged so that the timing of the injection during a run

of the engine could be changed, and these cards are the result. So far as the writer knows, this is the first time that a timing arrangement has been used on the fuel valve of the engine. The ignition of the fuel was obtained under conditions which undoubtedly were only possible in an engine which had been run long enough to get warmed up. It certainly seems a fair assumption that, if the fuel ignited as shown in these cards, it would have ignited if the clearance had been so increased that these low pressures were obtained at the end of compression. In these cards the fuel is shown as igniting from 70 pounds up to full compression of about 475 pounds. Card 11, where the igniting point or injection point was 130 pounds by the volume of the cylinder contents at 130 pounds pressure on the compression line as compared to the same pressure on the expansion line, makes it apparent that much energy is lost by radiation during the time of high pressure and high temperature. This loss at the end of compression should be somewhat reduced in the low-pressure type owing to the fact that, whereas the cylinder volume at the end of compression might be doubled, the radiating surface would be but slightly increased.

In order to get a better grasp of what was happening in the cylinder under different conditions the writer made a model for showing up the events of the stroke. The figures on Plate 22 for pressure and temperature were mounted on the edges of discs. The model showed the section of an engine with a movable piston. As the piston made two complete strokes these discs made one complete revolution. A disc for any desired condition could be attached to the mechanism of the model, and by moving the piston up and down the temperature and pressure for each position of the piston are shown. This emphasizes, even more clearly than the diagrams, the sudden changes in the cylinder.

Let us next consider the proposition that the ratio of air to fuel should be kept constant.

This has been done on the best gas engines as a means of governing. It has not as yet been done on the Diesel engine because apparently the full amount of air must be compressed per stroke in order that the igniting temperature may be obtained. The writer in March, 1913, brought this out in *Power,* where Figs. 1 to 3 of Plate 25 were published. In Fig. 1 referred to is a Diesel full load and Diesel two-thirds load card, and what was proposed at that time as a means for improving the present form of governing; that is, if only two-thirds of the fuel was used then only two-thirds of the regular amount of air should be compressed. A pressure curve was plotted in each case having crank angles for abscissæ. If the friction loss is a function of the pressure per square inch of the piston then the friction of the Diesel two-thirds load condition would be 50 per cent greater than in the proposed form of governing. This can be stated in another way. The friction is not a percentage of the net load but is a percentage of the work done in the cylinder regardless of whether the effect is plus or minus on the brake.

Figure 3, Plate 25, shows the way the efficiency varies with engines having different clearances. Fig. 4, Plate 25, is a set of curves constructed from tests made by Professor Denton in 1898 on a small Diesel engine. Improvements have been

made in the present engine but the cycle is unchanged, so that results obtained in these early tests are at least indicative of what is obtained in the present engines. This shows that the friction is practically constant at all loads, and would rather seem to bear out the contention that the friction is toll taken out of both the compression and working strokes. With the compression pressure constant the sum of the compression work and expansion work would vary but little for a great variation in the net work done in the cylinder. However, the sum of the compression and working strokes would vary greatly if the compression pressure were decreased.

Air is compressed and then expanded. The air in itself does nothing. All the work put into compression of the air will be given up in the expansion except the losses. Now if the quantity used per stroke be reduced the losses per stroke will be reduced by this same amount. Unnecessary compression of air is an extravagance. It is needless to compress more than is required for the proper combustion of the fuel.

We will next consider the problem of extreme slow speed.

In order to reduce to an extreme slow speed care must be taken to obtain a maximum temperature at the end of the compression stroke. Cards 9, 10 and 11, Plate 25, show the effect of cooling at the end of compression. For moderate speeds with a falling horse-power the amount of air compressed per stroke in the cylinder can be varied. Under present conditions there is a limit to the speed of the oil engine. At this limit the ignition will be uncertain. To go beyond this limit in the present engines the air should be heated before it enters the cylinder and the temperature of the jacket water should be raised. It might be even wise in an emergency to cut out the circulating water entirely.

This need for this slow speed was painfully evident when the Diesel-engined ship Christian X fell in with a disabled ship in mid-ocean. Her speed range was from 80 to 140 revolutions per minute according to published data. It was also stated in the press at the time that the Christian X repeatedly passed tow-lines to the disabled ship only to as often part them. The press report of this meeting was not very full. However, presumably the best that could be done would have been to keep starting and stopping the engines in the hope of gradually accelerating their tow to the point where the line would stand the lowest possible speed of the engine.

A steam vessel under the same condition would have run her engine very slowly just enough to give steerage way until she had taken up the slack of the tow-line and then would have increased her revolutions gradually until the desired number was obtained. This is manifestly impossible in the present oil engine. In the plant proposed at the end of this paper the motive power would be steam. Like the steam engine, the proposed engine would start a few turns per minute with steam from her economizing boilers. These would have energy sufficient to run the vessel for an hour at least without the use of fuel. In addition to the speed under the use of steam in the cylinders, by the use of steam in the jackets the radiation loss for the compression stroke should be cut down. If in a low-pressure type of en-

gine a blower giving a pressure of 10 pounds be used on the intake duct and the air be heated, the speed can be reduced very materially.

At this point it may not be out of place to call attention to the fact that the internal-combustion engine is simply a heat engine. Up to the point of encountering lubricating troubles in the engine the cylinders should be kept as hot as possible. This is true whether extreme slow speed or maximum efficiency is required.

We may now discuss the advantages of fuel valve control as to timing, etc.

In the present oil engine the duration of the fuel injection does not take into account the amount of fuel to be fed or the speed of the engine. In one particular instance reported in the engineering press the fuel feed continued for 46 degrees of one revolution of the shaft. This engine was two-cycle, and hence the fuel valve was open for practically 12 per cent of the total running time. If an engine be slowed down to half speed, considerably less fuel will be used than when the engine is running at full speed. Notwithstanding this, the fuel valve is open for the same length of time. This necessarily results in a waste of injection air, the thermodynamics of which will be taken up later. If the fuel be injected early in the stroke, a rise in pressure can be obtained which will increase the efficiency of the engine. If the fuel be fed into the cylinder a considerable time after the end of the compression stroke, it is possible to reproduce in the oil engine the same result as is obtained in the explosion engine by retarding the spark. Thus it seems to be highly desirable to be able to control at will both the timing of the injection and the duration of the fuel feed.

The method of compensating the theoretical loss encountered in reducing the pressure of compression next calls for consideration.

If the compression pressure is reduced, the fuel injection can be hastened and combustion completed earlier in the stroke. If high compression pressure is used, then the injection of the fuel must be slow, as is now done in the Diesel engine in order that extreme pressure may be avoided. If the fuel be injected rapidly and timed for the end of high compression pressure, results are to be expected similar to those shown in Card 13 of Plate 25. At this point it might be interesting to note that our experimental work never resulted in a combustion pressure of over 900 pounds per square inch. However, upon investigation it was found that the indicator was jammed and that 900 pounds was the limit which the indicator could record with a spring of 400 pounds to the inch. A relief valve was then fitted in order to avoid dangerous pressures.

A high-compression pressure means a small clearance and a relatively large number of expansions. The large number of expansions is very desirable, but the full effect is necessarily lost through the slow fuel injection. Why this is so is shown on Plate 24. Assume that the card is divided into four similar cards by means of the adiabatic lines as shown. Each card may be considered separately. In the case of card D the average clearance is 16.1 per cent of the whole cylinder contents; hence card D has only 6.2 expansions. Card A, on the other hand, has 11.34 expansions. If the fuel be injected rapidly into a cylinder whose clearance gives

a compression pressure of 275 pounds, then the number of expansions will be 8, or the same as the average of this Diesel card.

We may now call attention to some of the benefits to be derived from reduced compression pressure.

In the engineering press the idea of reducing the compression pressure and at the same time of making up for this lower compression temperature by means of a higher temperature of the incoming air has been opposed, the great objection to this innovation being that the volumetric efficiency would be decreased; in other words, that the power of the cylinder would be reduced, making the engine more bulky. There are two different methods for using the reduction in compression. The original idea was to save fuel by a process similar to compounding. In other words, when only a partial load was called for, a partial cylinder of air would be compressed. If this were done by closing the admission valve at the middle of the suction stroke there would be formed a vacuum in the cylinder during the rest of the stroke and maintained during the first half of the compression stroke. A charge which was compressed in 4 inches of the stroke would be expanded for 8 inches. In this case volumetric efficiency will not suffer, whereas, in the present method of governing the engine at partial loads, the efficiency is handicapped by the presence of an unnecessary excess of air.

In the other case, where it is desirable to have a large plant installed with cylinders say 60 to 72 inches in diameter, it is practically necessary to reduce the compression pressure for reasons of strength. Without going into the practical impossibility of a large, high-pressure type of engine, let us assume that it is possible. Also let us assume a duplicate of this engine in everything except that the clearance is made larger; this will reduce the compression pressure. In the first case the cylinder contents will be equal to the piston displacement plus about 7 per cent, and in the other case it will equal the same piston displacement plus about 15 per cent. We have already seen that, after the Diesel has run for awhile and warmed up, the temperature of the charge compressed is much above normal; and from $PV = RT$ it is certain that as the temperature rises the specific volume will increase and the weight of air in a certain space will decrease. If, on the other hand, some scavenging arrangement were to be attached to each engine, more weight of air could be used in the low-pressure engine; consequently more fuel could be used and more power could be developed. Thus this main objection to the low-pressure type falls to the ground.

When the writer began this work he was not aware that the Diesel engine after a run could operate on a reduced compression pressure. He supposed that heat would have to be added to the incoming air in order to enable an ignition temperature to be reached. The theory that no preheat is needed to enable the fuel to be ignited at lower pressures, other than that preheat which is absolutely unavoidable in a normal engine, is sustained by actual experiments.

The economies possible in the injection air is the last point for discussion pretaining to the present type of engine.

In the injection air we have an engine cycle within an engine cycle. Each pound of air compressed and used for the injection of the fuel also does work after it has entered the cylinder. This air is unnecessary for combustion in partial loads at least. As a result its efficiency can be considered separately as if the air were used in a power plant. What will be proven in regard to injection air has some bearing on the general engine cycle. No good can come directly from compressing air. All benefits from compression must be felt indirectly. In the main engine cycle air is compressed as near as possible without radiation. Such radiation as goes on is accepted, not sought for, in the present Diesel type. It is intended to show in this paper that there is no Diesel cycle as such, but that there is one main principle which governs all internal-combustion engines and that this is the general principle which governs all heat engines. This principle is that the maximum temperature or temperature range governs the efficiency of the engine. This contention will no doubt be universally accepted in time at least.

From the best information available the injection air compressor must develop about 10 per cent of the brake horse-power of the main engine. Of this 10 per cent what care has been used in regard to maintaining an economical cycle? The air is compressed in two or more stages to 1000 pounds pressure and then cooled to the original temperature or lower. In the heat engine the efficiency is based upon the energy of the working fluid plus the heat added and minus the heat rejected, all divided by the total heat at the beginning of the working cycle.

The total energy in the air after it has been compressed to 1000 pounds pressure and cooled to its original temperature is exactly what it was in the beginning. All that the work of compression has done is to make a part of this original energy available. Our natural conception of the energy of compressed air would lead us to the consideration that the energy depended upon the pressure of the air. As a matter of fact the determining factor is not pressure but temperature. There are several simple proofs for this statement. One is:—"Isoenergic lines are lines representing changes during which the intrinsic energy remains constant * * *. It will be seen later that the isoenergic and isothermal lines for a gas are the same" (Peabody). When the air after having been compressed is cooled to the original temperature, it is brought back to the isothermal from which compression started.

This contention can be proven mathematically. The formula for work of expansion to the absolute zero of temperature and pressure is $W = PV \div (k-1)$. This formula considers a fixed quantity of air, that is, a certain weight. In the formula $PV = RT$, considering the same weight of air, P and V will be the same as in the formula for work. By substitution, the formula for work can be rewritten $W = RT \div (k - 1)$. R and k are constants, and the only variable in this formula is T, the absolute temperature. This new formula will give the work of expansion for one pound of gas.

The above academic consideration of the injection air is simply to bring home forcibly the fact that a waste is being made of one-half of the available energy of

the compressed air when this air is cooled to room temperature in place of being used at 1040° F. absolute or 580° F. glass temperature. This waste is worth considering since it is a percentage of 10 per cent of the power of the main engine.

If the injection air is used at this temperature of 580° F., just one-half of the fuel to run the air compressor will be saved, and there will be no difference in the operation of the engine. Before this can be wisely done, however, there is need for a redesigning of the fuel valve. The writer has done some work along this line, but unfortunately has nothing of value to offer at this time. It is his opinion that the valve should be simplified even if the pump is complicated. All valves of which the writer has any knowledge depend more or less upon capillary attraction. In other words, the present fuel valve is in its general principle and relation to the fuel pump nothing but the Brayton valve shown by Brayton in 1890. This is nothing against it more than the fact that Brayton was plowing virgin territory, and fifteen years of operation show need for a redesigning of the fuel-feeding arrangement of the engine.

In regard to the danger in using air of this temperature there is this to say:— Any explosion in the injection line will come from a quick opening of the air valve. If there is a pocket in the line where oil can settle and the air valve is suddenly opened with no pressure in the line, the body of oil will be dislodged from its pocket and shoved along ahead of the incoming high-pressure air compressing the low-pressure air. If this action in the injection line takes place quickly the body of oil will take the place of a piston, and the action in the injection line will be the same as in the cylinder during the compression stroke. A temperature of ignition will be reached in the injection line regardless of the temperature of the injection air. In fact the explosion is caused not by the injection air but by the contents of the air line when the high-pressure air is turned on. It is possible to safeguard this type of engine from explosion in the injection line by a little care in the design of the piping arrangement, etc., and the exercise of due caution in operation.

The present instructions for operation of the Diesel engine state that the cooling water from the jacket of the fuel valve should be cold to the hand. The writer feels that the fuel valves can be designed so that it needs no jacket whatever. This may be objected to as an unsupported opinion, but it is based upon years of study along this line of work during which nothing has been found to oppose this idea and everything points to its possibility.

In closing let us consider the proposed thermo plant.

The writer is aware that the trouble with reformers is that they tear down without constructing and often leave chaos where order existed. For this reason, after having criticized extensively the existing order of things, it is felt that a statement of the writer's ideal might not be out of place.

Before describing this ideal the writer wishes to make a plea for charitable consideration. This does not mean freedom from attack, but merely freedom from that line of comment which he has met constantly for the last twelve years.

Our brother engineers in other lines are conquering the air with their planes, and space with their wireless spark, and are teaching us that the once indivisible atom is really composed of hitherto unknown finer subdivisions. We, on the other hand, are apparently contented with the wonderful efficiency of the present engine and are discarding at least 60 per cent of our generated British thermal units without any effort to recover this loss. This thermo plant is an attempt to profit from objections found with the present internal-combustion engine and to conserve as much as possible of this present waste energy.

Briefly stated, in this new type of engine plant the starting energy is steam generated in a special form of boiler. Before starting, the steam is admitted to the jackets of the engine warming it to a point where starting steam can be used without excessive condensation losses. After the engine is in operation from the effect of combustion in the cylinder the flow through the jackets is reversed, water from the bottom of the boiler is entered at the bottom of the jacket, and a mixture of steam and water comes from the top and is returned to the boiler. In this case combustion in the cylinder will not increase the temperature of the jacket water but will transform it from water to steam at the same temperature. Also, the exhaust gases from the engine will pass around and through this boiler before being rejected, and as much as possible of this waste heat will be converted into steam. The energy from the boiler will be used to run the auxiliaries and, if the idea of the writer is correct, to run a separate steam propelling plant. The exhaust from all steam units will be returned to a condenser, where at last the remaining heat units will be abandoned as unavailable energy.

In a plant of this type it will be possible to build units of great size with low compression pressure. As has been shown in the early part of this paper, this can be done without sacrificing any of the present thermal efficiency, but with a gain in mechanical efficiency. The one chief objection which has not been overcome in some form of a prime mover now in actual operation is the problem of lubrication. With the crosshead type of engine and lubrication of the cylinder through the piston it would appear that this problem would not be a hopeless one to solve. Care would no doubt be needed to provide for the presence of water completely covering the top of the cylinder head to prevent a steam pocket with a possible excessive temperature. This would mean the necessity of providing a more elaborate system of circulation of cooling water than has been shown in the diagrammatic sketch. The engine, as well as all piping, would be lagged to prevent radiation. Increasing the temperature of the cylinder walls should have an effect to increase the thermal efficiency of the engine itself.

The writer is pleased to extend his thanks to Professor Peabody for his kindness in going over this paper while in an embryonic condition and for his valuable suggestions. The writer is also greatly indebted to Mr. W. C. A. Sieverts and others, and especially to Dr. Geo. H. Ryder for invaluable aid given over an extended period during which much of these data was collected. Many valuable suggestions and much encouragement and aid have been received in the last twelve years from Mr. F. R. Low, Editor of *Power*.

DISCUSSION.

THE CHAIRMAN:—We are much indebted to Mr. Wentworth for the presentation of his interesting paper, and we would like now to have a good discussion on it. (A pause.) The Chairman would be very glad if the gentlemen discussing this paper quietly amongst themselves would discuss it more publicly for the information of all. While this is not a "hot air" engine, by any manner of means, we would all be pleased to have a full expression of views. The Chair feels sure that Mr. Wentworth is not so certain of everything that he has said that he would not like to have some one criticize his statements.

MR. WILLIAM N. HOWELL, *Member*:—I carried out a number of experiments for the Lake Torpedo Company extending over about two years, and among other experiments we had a boiler through which the exhaust gases from a Diesel engine were passed, and the trouble with it was sooting up of the tubes. The Diesel engine is supposed to work when conditions are favorable with no soot at all in the exhaust, but that only obtains when conditions are entirely favorable. If there is any trouble with the fuel injection, which often does occur, there is much soot, and, in all experiments of boilers connected with the exhaust of Diesel engines that I know of, this has been an insurmountable objection. Apparatus had to be provided to keep the tubes clean, and it was found to be practically impossible to get good results from any kind of boiler connected with the exhaust.

THE CHAIRMAN:—The paper is still open for discussion.

MR. W. R. HAYNIE, *Associate Member*:—Mr. Wentworth refers to the variation in the injection air pressure as having a bearing on the results of Diesel engines, and, following up Mr. Howell's suggestion of existing soot, I will say that the soot is really the result of incomplete combustion of the product used in the engine from which they want to utilize the heat contained therein.

But, working back, after all, it is a question of combustion. Unless you can get complete combustion of the oil or fuel (whether solid or liquid) which is injected into the engine, you do not get all the heat contained in the oil. In the Diesel practice it has not been proven by experience so far that you can do this by higher pressure injection of air. This air does not mean any factor of energy at all, but a means of disintegrating the particles of oil, so that the heat energy in the oil can be obtained by complete combustion.

There are two questions—high or low pressure? If you are able to get greater benefit from a lower pressure of air than the Diesel theory of high-pressure air for disintegrating, or breaking up, or pulverizing the particles of oil to get the heat content from the oil in expansive force, it is better. I do not mean this as a criticism of Mr. Wentworth's paper, but there was a question in my mind which I could not get clear from my experience in this line.

I do know from experience and from tests that by a lower-compression pressure and by eliminating high-pressure injection air you can simplify the mechanism in the prime mover at a sacrifice in the volume of oil injected, or in the percentage of efficiency, any way you want to term it, and yet get complete combustion. In other words, there are really two general problems before the mechanical world to-day in this type of prime mover as applied to marine service, one being the high-pressure engine, with a number of mechanisms

necessary to obtain and use the high-pressure air for injection; the other the low-pressure engine which gives the same effective service results at a sacrifice of economy which varies from 8 to 12 per cent.

THE CHAIRMAN:—If there is no further comment the Chair will call on Mr. Wentworth to respond.

MR. WENTWORTH:—In regard to what Mr. Howell said about the soot, I would like to object to that point, because I do not think anything is impossible until it is tried out. There is no doubt there would be a good deal of difficulty, as Mr. Howell said, but I do not think it is insurmountable, because the fact that it is in commercial use to-day seems to me to prove that it has possibilities.

As far as what Mr. Haynie said, it seems to me that he has missed the point. If you take the same high-pressure engine that you are using to-day you can increase your temperature at that same pressure of injection of air and get the same effect of breaking up the oil, with just half as much power put into the air compressor, and the engine into which the oil is injected will not show the least diminution of power, so that you have a clear gain of just one-half of the compressor power.

When I say "low compression," I refer particularly to the compression of the working air in the cylinder, not the injection air. If you do reduce your pressure of compression in your working cylinder, you can reduce your compression of injection air, that is, it is the difference of pressure that breaks up the oil. For instance, we did run my experimental engine until it was stopped. I confess that I made a mistake—I attempted to design not only an engine but an air compressor. I bit off more than I could chew, without any question. I had all kinds of trouble and the pressure would not hold up. We would start with the air pressure away up, and run until we got out of breath, so to speak, but we could run with a very low injection of air. The idea is to keep the compression of your injection air a reasonable degree over the compression in the cylinder; but you must, to get the full benefit of what I had in mind, feed the air in hotter or use hotter air for injection of the fuel.

MR. HAYNIE:—In using air, is it not a fact that the injection air is used largely for two purposes? In the true Diesel or original Diesel, it was used as force to blow the oil into the engine as well as to pulverize it?

MR. WENTWORTH:—Yes.

MR. HAYNIE:—With the lower pressures that you refer to, it is not possible to always follow that line, but you do have this value of disintegrating the particles, or breaking up the particles of oil by impregnating it with air at some given pressure; just what the ratio of that pressure is, is as yet an undetermined factor. I do not like to use trade names, but you can take six or eight European engines built to-day which have obtained records in service that are very enviable, and they all use a small volume of air injected with the oil at the proper point, and while the oil is injected by pump pressure you break up the particles of oil with air so that you get more complete combustion and eliminate the soot Mr. Howell speaks of. Soot or carbon is the result of incomplete combustion, so if you break the oil up into small particles or pulverize it by frequent blasts of air, you get complete combustion if you get any combustion at all.

It is a fact that through the lower compressions in the cylinder Mr. Wentworth speaks of, you are able to obtain reliable and continual service without the maintenance of an enormous series of valves and cams, and the setting of these valves and cams, as in the high-cylinder compression that has been formerly used, necessitating a very tedious, insecure and unreliable system of lubrication. Owing to the high-compression pressure of some of the Diesels which have been put in service, we found it was almost impracticable to lubricate the cylinders all the time. In one case en route from London to New York, we had always the question of lubrication of the pistons. If we could do that, we would get to New York on schedule time. By the lower compression we obviate that condition, also the high temperatures created by high compression, and by the breaking up of the oil with a mixture of air you can get complete combustion at a lower-compression pressure which follows the curve of temperature.

Mr. Howell:—How do you handle the question of compression in the cylinder? I have seen a patent in which there was a plunger arrangement so that the compression could be changed in the cylinder of the Diesel engine or gas engine, but it seemed to complicate the apparatus, and when you consider the number of valves and fittings and cams on the engine now, it seems to complicate and add more apparatus.

Mr. Wentworth:—If your imagination will allow you to consider this a valve-cam going this way (drawing diagram on the blackboard) I will show my method of procedure. I had two cams—it was an experimental engine, a single-cylinder engine—one cam here, representing partial load, and this representing full load. This would take in the full cylinder here (indicating) and this one the partial load. That would give a pressure of compression of about 390 pounds. I think the way to get the best results would be to keep this valve-cam constant; here is your fulcrum and here is the cam action. This valve is held seated by this heavy spring and also by this light spring. If you depress this heavy spring (indicating), then you have nothing but an automatic valve spring to hold the valve tight. Then if this is rotated with regard to your cam shaft, this action will not amount to anything, except to close the valve; in other words, this will close the value and the automatic, light spring will let it open at the proper time. This would seem to be a complicated way of arriving at it on a fuel valve to provide for injection—that was the original form and we modified it. This connection was broken and a rounded seat made in here. I had a hand wheel put on so that I could pull one side or the other. In other words, here is the center line and here is the point. That was broken there and brought over this way, and in that way I can get direction, but at the same time it enabled me to vary the fuel injection, without any great expense, on the experimental model. We started with the fuel injection at the dead point. That would enable us to get an engine running. Once we got the engine running, got things warmed up by this means, we could advance the injection and still keep the engine running.

Mr. Wentworth (Communicated):—Examination of the stenographic report of this discussion brings out a few points which escaped my notice during the discussion on the floor.

First, in regard to the remarks of Mr. Howell on sooting which he found to make the use of exhaust gas impracticable as a means for generating steam, let me quote from the *Power* of June 30, 1914, page 921, the correspondent said to have been chief engineer of a Diesel ship for the past eighteen months.

"It should be mentioned that all auxiliaries are steam driven, one oil-fired boiler being fitted on deck for port use and a smaller one in the engine-room for use at sea. Firing is accomplished partly by oil and partly by the exhaust gases from the engines. The boiler is of the ordinary marine type, having two furnaces, so that the gases are continually passing through one furnace, to act, in the first place, as a silencer, and in the second to utilize the waste heat from the exhaust. The second furnace is free for an oil burner, but we find it unnecessary, as, with the steering and other small engines usually working at sea, sufficient steam to drive them is generated by the exhaust gases alone, which is a great saving."

This has a bearing on the practical value of the economizing boiler.

Second, Mr. W. R. Haynie, in speaking of the low-pressure engine, said, "which gives the same effective or service results at a sacrifice of economy which varies from 8 to 12 per cent."

In the plates accompanying this paper there is shown a figure illustrating the loss in the slow injection of the fuel (see Plate 24). If you consider that the thermal efficiency of the normal high-pressure Diesel engine is no better than could be obtained with compression pressure of 275 pounds, as shown by this figure and brought out at the bottom of page 80, then the error of the statement made by Mr. Haynie that the low-pressure engine has a lower efficiency will at once be apparent. Mr. Haynie speaks as if low-pressure engines were on the market. The hot-head engine is in a way a low-pressure type. That should not be confused with the low-pressure type proposed. The hot-head type is limited to small sizes. As brought out in the paper any Diesel can run on low compression provided that it can first be warmed. This is, however, an impossibility for a Diesel engine. While Mr. Haynie did not bring up the reduced power in the low-compression type that is a more common fallacy than the low-efficiency idea.

Third, Mr. Haynie asked: "Is it not a fact that the injection air is used largely for two purposes? In the true Diesel or original Diesel, it was used for force to blow the air into the engine?" My answer was, "Yes." It should have been "No" and "Yes." Injection air in all cases is used only to force the oil into the engine. This is taken up at the top of page 82 of the paper.

In his last remarks Mr. Haynie said: "By the lower compression we obviated the high temperatures created by that compression, and by the breaking up of the oil with a mixture of air you can get complete combustion at a lower compression pressure which follows the curve of temperature of course."

This seems to infer that in an engine it is possible to reduce the pressure of compression, and hence the temperature of compression and make-up for this reduction by a change in the condition of the fuel injected. The writer's experiments do not bear this out. He has found there is but little difference in the compression, and hence the temperature needed to ignite all fuels. Experiments with different fuels seem to indicate that the fuel must be broken up into a spray in order for the temperature of the compressed air to act at all. Then, if the fuel is properly sprayed, the temperature of compression must be around 1,000° F. We found it to be impossible to start our experimental engine on those nights when the shop and engine were both cold—close to 32° F. We got no results, regardless of the fuel which we used. The same engine adjusted in the same way would start on heavy oil if the shop and engine were around 60° F. It appears that while the pressure of compression can be lowered in the oil engine the temperature of compression must not be lowered.

THE CHAIRMAN:—I am sure you will desire to thank Mr. Wentworth for his contribution to our information on this subject. The discussion was slow in beginning, but this indicates that the human mind is like an engine—it needs to be warmed up a little to get it in good running condition.

The next paper on our list and the last for today is No. 4, "Launching Data for a Battleship," by Naval Constructor J. G. Tawresey, U. S. N., Member.

Mr. Tawresey presented his paper.

LAUNCHING DATA FOR A BATTLESHIP.

By Naval Constructor John G. Tawresey, U. S. N., Member.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

The launching of a great ship is always a matter of interest to the profession, and one of anxiety to those responsible. The experience from an unbroken series of successful launches, backed by the knowledge that every condition has been investigated and every precaution taken, is not sufficient to entirely banish the thought that there may be some unusual factor for which allowance has not been made. The data for some previous vessel, especially one of corresponding dimensions and weight, are the basis of the launching arrangements adopted for a new vessel, and the great value of such data, when full and reliable, is considered sufficient reason for adding the following notes on the launching of a battleship to the valuable papers on launching already contained in the Transactions of the Society.

Papers on launching are published in the Transactions for the years 1894, 1900, 1903 and 1904; they give full data for a great variety of vessels and for a considerable range of launching weights. The tables and plans herewith for the U. S. S. Oklahoma, a 27,500-ton battleship, 575 feet long and 11,965 tons launching weight, will serve to bring the recorded data up to date and to extend it to larger and heavier vessels.

The Oklahoma was launched at the New York Shipbuilding Company's yard, Camden, N. J., on March 23, 1914. Much of the following data is taken from the regular report prepared by Naval Constructor E. G. Kintner, U. S. N., for the records of the Bureau of Construction and Repair, Navy Department. Through the courtesy of the New York Shipbuilding Company, I am able to include the launching plan and the launching curves, prepared by the Company's naval architect, Mr. E. H. Rigg, one of our members.

The launching was considered entirely successful, and the statement of data is presented as showing regular practice for large vessels, not as an example of novel methods. All of the arrangements had been used for previous launchings. The arrangement of cradle, packing, shoring, etc., is shown on the plate of launching plan. Dog shores were used as preventers and safety devices; the vessel was actually released by means of the hydraulic triggers now generally used for large vessels. The arrangement for distributing the pressure at the fore poppets when the vessel lifts is worthy of note—a rocker or segment of trunnion of 50 feet radius. It was first used for the U. S. S. Arkansas, and has now been used for a number of vessels and is effective.

It is interesting to note the development of fore-poppet arrangements, from that for the small vessel with fore-foot resting on a cross log and no arrangement for distributing the pressure to the arrangement of suspending lashings, two or more of chain or wire rope with little stretch, and forward of these two or more of rope with considerable stretch that tends to equalize the pressure as the vessel lifts, an arrangement that has served well even for quite large vessels; and, finally, to the arrangements now used successfully for the largest vessels, either that used for the Oklahoma or the crushing-chocks or gratings with the area in contact proportioned so that where the pressure would reach a dangerous maximum the wood crushes and compresses, and by yielding throws a part of the pressure further aft and thus effects the necessary distribution. Large metal trunnions, with cast steel and built-up saddles of extent sufficient to distribute the pressure, have also been used. Crushing-chocks are described in Mr. James Dickie's paper on the "Launch of a Cruiser and a Battleship," Volume VIII of the Society's transactions.

The depth and breadth of channel opposite the Oklahoma building slip are such that no checking arrangement was required. Efficient checking arrangements are described in the different papers on launching. Manila cables, attached to anchors or other fasts on shore, are sometimes used for checking and to have the stretch of the cable stop the ship gradually. Manila cables appear unnecessary, as it is generally practicable, and more economical, to use the vessel's chain cables. The chain cables, if attached at some height above the ground, will bring the strain up gradually, in the same way that the strains are eased for a ship at anchor by paying out a good scope of chain. An error is sometimes made in estimating the checking effect in breaking rope stops by assuming that it is the same as the work done to stretch the rope stop to the breaking point. That is correct if both chains are stretched out along the slip and the one attached to the ship secured, say at the fore-foot. Ordinary practice is to attach it high up on the vessel; when the strain first comes on the stops the chain will hang in the curve of a catenary from the point of attachment on the ship to some point where it touches the ground and extends along the slip to the stop. As the vessel continues to move and the strain increases and the stop stretches, the part of the chain in contact with the slip decreases, the part hanging in a catenary lengthens and becomes flatter, and it will be found that the ship moves through an appreciably greater distance than the stretch of the stop, and that the work done in checking the ship is proportionately greater than that in stretching the stop. The chain cannot push the ship, and no part of the work done in lifting the chain is restored to the ship when the stop parts and the chain surges and falls as the next stop begins to stretch.

The launching curves, Plate 37, are of the usual type. The curve of way-end pressures, now generally used, is worthy of note, as it is a criterion relative to internal shoring as well as for needed support at the ends of the ground ways. The curve of way-end pressure is considered in Mr. Everett P. Lesley's paper on "Launching Practice on the Pacific Coast," Volume 12 of the Society's Transactions.

The curve of launching velocity and derived curves, Plate 38, are based on

observations with a regular moving-picture camera using standard film and taken exactly as for a moving-picture exhibit. The camera was mounted on the gallery of the adjoining building slip, at a known height and known distance out and known distance from the ways on which the Oklahoma was launched. Its axis, unfortunately, was pointed at a considerable angle instead of normal to the vertical plane through the launching ways. It was inclined both downward and toward the head of the slip, as will be seen from the distortion shown in the photographs. The distortion increased appreciably the work of obtaining correct readings.

A scale graduated in feet was erected on the framework on the opposite side of the building slip about 126 feet from the camera. The marks on the scale are two inches wide. A large clock, with 18-inch dial, was altered to run at approximately sixty times its normal speed, so as to indicate minutes and seconds instead of hours and minutes. The escapement was replaced by a fan regulator to secure steady motion. The clock was suspended at a distance of 15 to 20 feet from the camera in a position such that the clock, the scale, and a part of the vessel would show in each picture. The short focus of the lens allowed the clock, the scale and the ship all to cut sharp.

Marks were placed on the ship at known stations, as at the 19-foot waterline, and at frames 5, 15, 25, etc. These marks, 3 inches wide, were painted in black on the white bottom paint, and were identified by large numerals also painted black.

The clock, which had been previously rated, was timed with a stop-watch for five minutes just before the launch and again immediately after. The rate was satisfactorily constant, and was applied in determining the time plotted on the curves.

The taking camera was started on a signal received two minutes before the hydraulic trigger was released. The vessel did not start promptly and the operator stopped and thus lost the actual start of the vessel; moreover, some of the pictures at the beginning of the film were cut off and not furnished, so that the first picture and the first observation spot are after 6.8 seconds from the start when the vessel has moved 7.33 feet. The film consists of 695 pictures, taken approximately sixteen a second; the actual rate is found to vary generally 6 per cent over or under, and at times as much as 20 per cent over or under.

After several trials it was determined that a low-power microscope is the best means for reading the film. It was found to give accurate results, and it can be used by an individual at his convenience. The pictures cannot be held stationary on regular moving-picture projectors on account of the extreme heat, and ordinary magic lanterns do not give sufficient light. Trial was made on a special lantern that gave satisfactory light and magnification, and that allowed the picture to be held indefinitely without being affected by the heat. It was found, however, that the pictures were not distinct when viewed from close to the screen, and as that method required electric current, a large dark room and an attendant to be available, the microscope method was preferred.

A microscope was obtained with cross hairs and special rotating gear for the eye-piece. There is a reading circle and vernier that allows readings to 0.25 of one degree, or with the camera pointed directly at the clock to one-twenty-fourth of a second of time when used to determine the position of the clock hand. A mechanical stage, with traverse motions at right angles and with verniers reading to 0.1 mm., was used to hold the film and to read the position of the marks on the vessel relative to the scale, and for other readings.

Plate 31 is a reproduction of a part of the strip of film exact full size. The film used was a positive, not a negative. Plate 32 is a reproduction of picture No. 428, magnified six diameters. It is one that is included on Plate 31. Plate 33 is a view of the clock from picture No. 428, magnified thirty-one diameters, the magnification used for reading the film. Plate 34 is a view of station 65 from picture No. 428, showing a reading between 20 and 21 feet on the scale. This view is also magnified thirty-one diameters. The exact reading is obtained by taking for the excess over 20 feet, the proportion of one foot that the distance in millimeters from 20 feet to station 65 measured by the vernier on the mechanical stage, is of the distance from 20 feet to 21 feet measured in the same way.

Both Plates 33 and 34 are very accurate representations of the exact size and appearance as viewed through the microscope. Half of the clock face was in shadow, and the difference in appearance of the two sides is less than that shown on Plate 32. It was attempted, in making the enlargement, to reduce the difference to that actually appearing when viewed through the microscope.

The method of plotting the curves, Plate 38, first on distance with a horizontal base, next on time, is evident on inspection. The distance traveled, the velocity, and the acceleration are all measured in foot-second units along the horizontal base drawn at the actual height of the tide at time of launch. To obtain corresponding values parallel to the ways, multiply by the secant of the angle of slope, that is, by 1.0016. The actual observation spots for the distance curve are shown by small circles. A point is obtained for each picture read, and as many points may be obtained as desired.

The dotted portion of the distance curve before the first picture was obtained as follows:—The initial position of the ship on the ways was known, thus giving an origin of distance but not of time. Points "A" and "B" had been observed independently by stop-watches by observers at the head of the ways, right at the marks where they had an opportunity to get good observations. The known part of distance curve was prolonged back to the known origin of distance and to pass fair through "A" and "B" plotted to the same scale, and the origin of time for "A" and "B" thus located was taken as the origin of time for the whole curve.

The points plotted as + and × are two independent series of stop-watch observations for time and distance run; they were made according to the method described on page 258, Volume II of Transactions of the Society of Naval Architects and Marine Engineers for the year 1894. The observers were necessarily at some little distance from the ship, in order to see the station marks when the vessel

is moving rapidly; that places them in a position where they cannot properly observe the instant that motion starts. The origin for time, for these observations, is therefore subject to considerable uncertainty; it was adjusted as described for the moving-picture curve observations.

The points + and × lie surprisingly near the accurate curve, except for observations near the origin.

The remaining curves were derived by the usual methods, the differentiation being performed numerically on measured ordinates, rather than by drawing tangents. As a final check the whole set of curves were reintegrated and adjusted, so as to be correct and consistent for individual parts as well as for the curve as a whole. It will be noted that the derived curves are plotted on a very large scale.

The position of the ship entering the water at point of maximum velocity after 100 feet travel is worthy of note.

Pivoting would occur at "E" after 459 feet travel on the assumption of static conditions (see Plate 37). It actually occurred at "F" after about 569 feet travel. The over-run due to vertical component of velocity is estimated as 10 to 12 feet, leaving about 100 feet to be accounted for by the difference in static and dynamic conditions.

The coefficient of friction and resistance was obtained by differentiation, as previously explained. It was also noted that the vessel did not start promptly, but hung for several seconds. The coefficient of "starting" or "sticking" friction was estimated from that fact, and the known inclination of the ways, and is plotted at "G." That the curve does not begin at "G" is due to the sensible origin of time and motion not corresponding to the actual origin. They would correspond, no doubt, were we able to observe minute movements at the start.

A portion of the distance curve "cd" is reproduced to a greatly enlarged scale "CD" at the top of the sheet. The seven double spots represent two determinations of travel from each of seven pictures, on which two stations on the ship show in positions to be read on the scales. If the determination of travel is exact, including reading of film, formula, constant distances, co-ordinates for location of camera, and the numerical calculations, then the difference for the pair on any one picture should be the exact known distance between the stations on the ship, and the spots corrected for that distance would plot one on the other. The variations for the seven pairs "C" to "D," disregarding signs, are, in feet, 0.21, 0.31, 0.10, 0.07, 0.03, 0.34 and 0.31. Considering the above quantities as errors, we find the probable error of a single observation to be 0.16 feet, or 2 inches; that is, by method of least squares, the error that it is an even chance that any error exceeds or falls under.

In all twenty pairs of readings were made similar to the above, and the probable error determined from the whole twenty, including the seven on portion of curve "CD," is 0.21 feet or 2½ inches.

The distance the vessel moved before lifting was much greater than expected; in fact it was assumed, without very much consideration, that as the differ-

ence between actual dynamic conditions and the assumed static conditions lessens the tendency to tip, it would increase the lifting moment about the fore poppets and cause the vessel to lift sooner. The obstructions between the camera and the ship prevent a full investigation and measurement of the waterline on the picture record; it was found, however, that the wave at the stern is followed by a great hollow and great reduction of depth of water over the ways and at the end of the ways, in wake of the middle body of the vessel, when lifting was estimated to take place. The over-run and deferred lifting does not lessen the maximum pressure on the fore poppets when the vessel does lift. On the contrary, if it is caused by a transfer of displacement from amidships to the after end, the same lifting moment is reached with a less total displacement, and consequently with somewhat greater pressure on the fore poppets.

The coefficient of initial friction is a matter of great interest. The observed points near the origin on the distance curve are not sufficiently numerous and accurate to allow it to be determined by differentiation. A slight modification of the distance curve, such as would be made in fairing, will cause a great variation in the derived acceleration and coefficient of friction. The initial friction could not be determined from the pressure in the cylinders of the hydraulic triggers, for the reason that they were pumped up to a pressure tending to force the ship up the ways, to be sure that she did not settle on to the dog shores. The pressure in the cylinders was therefore greater than it would have been had the vessel been allowed to settle on to the triggers, and the pressure in the cylinders to regulate itself to the amount necessary to make up what friction lacked to prevent the vessel from starting.

The different papers on launching describe various types of chronographs for observing the time and distance run, from which the velocity and other functions are found. A photographic method was devised by Naval Constructor E. F. Eggert, U. S. Navy, about 1905, and used very successfully for the Mississippi and the Kansas. Now that moving-picture cameras are available, they offer the readiest means for obtaining photographic records. Photographic methods have such an advantage where simultaneous observations are required, that arrangements are now in hand to use a moving-picture camera to record the observations and data for tests on ships' auxiliaries, such as training turrets, operating test on boat cranes, etc. It provides for accurate simultaneous records of the time, the position of the moving part, trim of ship, heel of ship, position of controller, and readings of ammeters and voltmeters, as they all appear in each moving-picture, and give the data to calculate the power, velocity and acceleration. The method, in addition to giving accurate records, obtains them in the shortest possible time.

The arrangement for picture record of the Oklahoma's launch was made to suit the conditions as they existed, and with but limited consideration in advance. Plate 35 has been made up to show a more convenient arrangement. The axis of the camera is pointed normal to the vertical plane containing the scale and is at the level of the center of the scale. The scale is given the same inclination as

the ways, but is graduated for horizontal travel. The marks on the vessel are made as verniers, so as to read to one-tenth of a foot. They are attached to the vessel so as to stand parallel to the scale, and to project just above the scale in the picture. The marks or verniers on the ship are placed so that before one leaves the scale the next one comes on; each is laid out for the position it will occupy on the ship, and is expanded over the size of a vernier at the distance of the scale, in the proportion that its distance from the camera when crossing the axis of view is to the distance of the scale where it crosses the axis. The clock is placed so as to show in the center of the picture, just under the scale. A vernier is added to the long hand so that with sufficient magnification the clock reads minutes, seconds, and tenths of a second. It is also advisable to add two vertical scales for use in determining the trim, the position when the vessel lifts, and for measuring the height of the waterline.

It is not suggested that moving-picture data is desirable for all launches; the curves, Plate 38, show that stop-watch observations, carefully made, give reliable information. It is to be noted, however, that dimensions and launching weights change; practices, precautions and other launching conditions change; the kind and quality of materials that must be used change; and it is advisable that launchings be rigidly investigated from time to time and that accurate observations and records be made. Photographic methods offer advantages to that end.

Parts of the launching operation deserving further investigation are the start, and the waterline just before lifting. The latter can be studied from the record of one or two moving-picture cameras placed to give a clear view of the waterline, and of vertical gauges and scales. Information as to actual start and initial friction would be obtained from a moving-picture record taken by a camera close to the forward end of the ways, to give a large-sized view. A long reading pointer could be attached to the ways to magnify the movements for the first inch of travel.

The over-run before pivoting is influenced by surrounding obstructions that interfere with the free flow of water to the ways, and by the proportion of the prism-section of the vessel to the prism-section of the water in the slip, as well as by the velocity. A mask used across the stern for checking tends to increase the over-run, and it may happen, due to the various causes, that the vessel not only over-runs the estimated pivoting point, but also has a tipping moment in excess of that estimated for static conditions.

U. S. S. Oklahoma.

LAUNCHING DATA.

Type of vessel ..... Battleship, First Line
Builders ..... New York Shipbuilding Company, Camden, N. J.
Date of launch ..... March 23, 1914

PRINCIPAL DIMENSIONS, ETC.

Length between perpendiculars		575 ft. 0 ins.
Breadth on load waterline		95 ft. 2½ ins.
Mean draught		28 ft. 6 ins.
Displacement		27,500 tons
Percentage completion at time of launch		61%
Weights worked into vessel, tons	11,765	
Temporary weights on board, tons	85	
Men, tools, and dunnage, tons	115	
Launching cradle, tons	470	
Total launching weight		12,435 tons
Draught after launching, forward		13 ft. 7 ins.
Draught after launching, aft		16 ft. 4 ins.

BUILDING SLIP, LAUNCHING WAYS, CRADLE, ETC.

Declivity of building slip, per foot	11/16 in.
Declivity of keel blocks, per foot	11/16 in.
Length of ground ways over all	644 ft.
Length of ground ways submerged	167 ft.
Width of ground ways (each)	60 ins.
Thickness of ground ways	16 ins.
Declivity of ground ways, per foot	11/16 in.
Camber of ground ways	None.
Inclination of ground ways, transverse, per foot	⅜ in.
Spread of ground ways, center to center	28 ft. 6 ins.
Material of ground ways	Yellow pine faced with oak
Length of sliding ways over all	473 ft.
Length of sliding ways, effective	465 ft.
Thickness of sliding ways	15 ins.
Maximum width of sliding ways	58½ ins.
Effective width of sliding ways	57 ins.
Bearing area	4,420 sq. ft.
Material of sliding ways	Yellow pine faced with oak
Length over which poppets distribute pivoting pressure	23 ft.
Area under poppets to take pivoting pressure	220 sq. ft.
Projected length of curved bearing surface under fore poppets	21 ft. 9 ins.
Projected area of trunnion segment to take pivoting pressure	208 sq. ft.
Number of wedges, spaced 17-inch centers	590
Wedges, oak, 9 feet by 6½ inches, tapered ½ inch per foot.	
After end of sliding ways at start, up from water's edge	6 ft.

After edge of rudder at start, up from intersection of prolonged keel line and water, about	9 ft.
After perpendicular to after poppet bearing on ways	66 ft.
After perpendicular to after poppet bearing on ship	78 ft.
Forward perpendicular to forward end of sliding ways	44 ft.
Forward perpendicular to center of fore poppets	59 ft.
Means for distributing pressure at fore poppets	Rocker formed as a segment of a trunnion

PRESSURE, VELOCITY, COEFFICIENTS, ETC.

Total weight on ground ways	12,435 tons
Initial pressure per sq. ft.	2.82 tons
Maximum pressure per sq. ft. over ground way ends	5.3 tons
Center of gravity forward of center between perpendiculars	7.9 ft.
Distance traveled to calculated pivoting	459 ft.
Distance traveled to observed pivoting	560 ft.
Distance traveled from calculated pivoting to end of ways	181 ft.
Calculated buoyancy at pivoting	8,875 tons
Pressure on fore poppets at pivoting (neglecting buoyancy of packing)	3,090 tons
Pressure per sq. ft. under fore poppets at pivoting	14.05 tons
Pressure per sq. ft. on projected area of trunnion segment at pivoting	14.85 tons
Distance traveled to bring center of gravity over end of ways	410 ft.
Depth of water over ends of ways (actual corresponding to 5 ft. 10 ins. tide)	9 ft. 6 ins.
Least excess of calculated moment to prevent tipping	52,200 ton-ft.
Static drop of vessel where poppets leave the end of ground ways	6 ft. 4½ ins.
Average velocity first 100 feet (5.8 ft. per second)	3.3 knots
Maximum velocity (23.6 ft. per second)	Nearly 15 knots
(Ship hung 2 to 3 seconds and then started slowly without application of rams or other means.)	
Travel before rudder entered water, about	25 ft.
Travel to point of maximum velocity, about	100 ft.
Time to point of maximum velocity	17.25 sec.
Travel to point of drop, fore poppet at end of ways, about	640 ft.
Time to point of drop, about	41.6 sec.
Coefficient of starting (sticking) friction, about	0.0575
Coefficient of friction, average first 50 feet, about	0.026
Coefficient of friction and resistance, average first 100 feet, about	0.016

Coefficient of friction and resistance, minimum, about..... 0.004
Coefficient of friction and resistance, average after 250 feet run, about 0.06

MISCELLANEOUS.

The recorded weights at time of launch were subsequently confirmed by the observed displacement.

Method of release—hydraulic triggers.

Pressure used for triggers—Started with 250 lbs. per sq. in., and was gradually increased as blocks were removed to a maximum of 1,600 lbs. per sq. in. just before dog shores were dropped.

Temperatures on day of launch and on preceding days:—

Date.	*Maximum.*	*Minimum.*	*Mean.*
March 20.....	33° F.	22° F.	28° F.
March 21.....	34° F.	19° F.	26° F.
March 22.....	38° F.	14° F.	31° F.
March 23.....	45° F.	26° F.	36° F.
March 23 (noon), Temperature on building slip....			31° F.

Lubricant on ground ways, under fore poppets applied several weeks before launching—First a thin coat of stearine, next a 9/16-inch thick coat half tallow, half stearine.

On remainder of ground ways under sliding ways, applied two to three weeks before launching—First a thin coat of stearine, next a mixture of three parts tallow to one part stearine.

Remainder of ground ways to a point 36 feet beyond low-water mark, applied by means of cofferdams three to four days before the launch, and touched up the day before on account of damage from ice—Tallow mixed with lard oil.

Lubricant on sliding ways, applied two to three weeks before launching—Forward 80 feet thin coat of stearine, whole length with launching grease smeared on lightly.

Lubricant on pivoting surface under fore poppets—A mixture of half stearine and half tallow applied 9/16-inch thick.

Removing blocks, etc.—Some of the blocks at ends of vessel and most of the shores were removed the day before the launch.

Wedges were set by mauls and alternate keel blocks removed, starting at 7.30 a. m., on day of launch. Rallies on the wedges, using rams, were made at 10.00, 10.11, 10.22 and 10.32 a. m., the last block was out at 12.10 p. m., dog shores dropped at 12.13 and ship released at 12.15 p. m.

About 280 men were employed below the ship; some 40 of these afterward went on board, making about 120 men on the ship at time of launch.

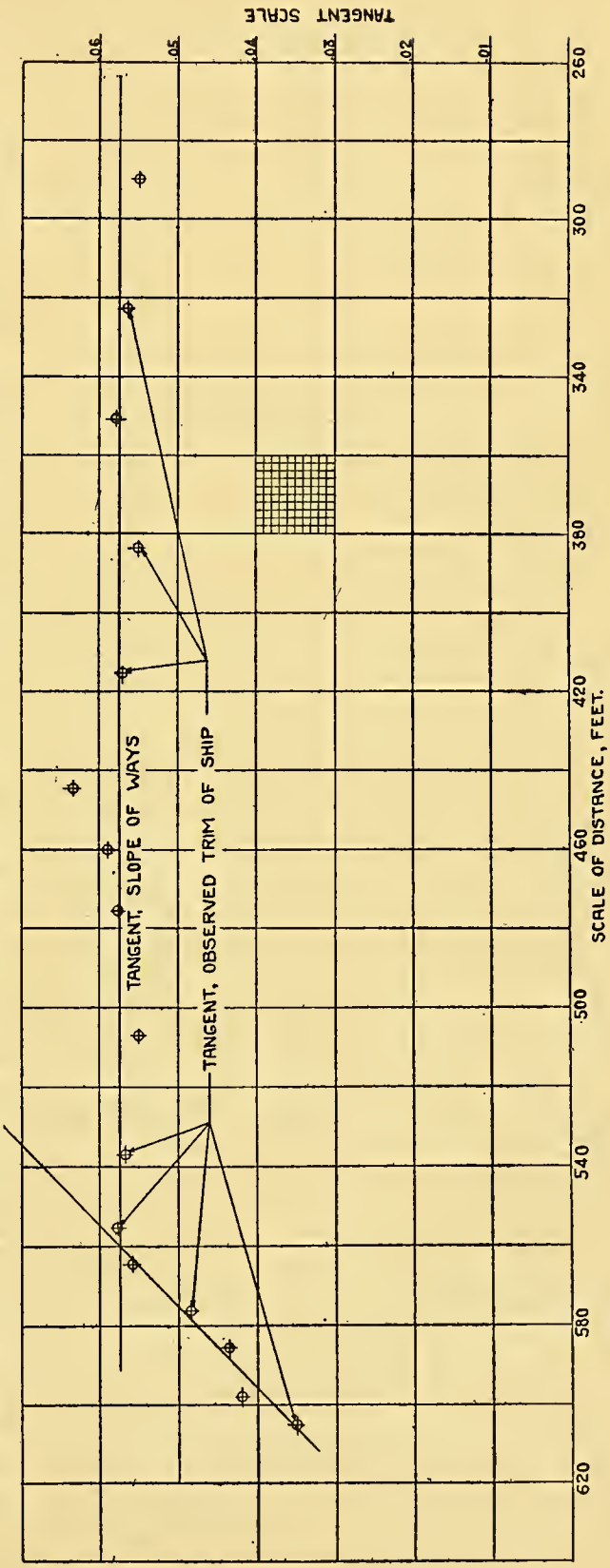
Vessel was launched just as tide was turning ebb; there was a moderate breeze from the southwest.

DISCUSSION.

After reading the paper, Mr. Tawresey said:—

"Since writing the paper I have learned that the photographic method was used in determining the launching velocity for the battleship Delaware built by the Newport News Shipbuilding Company; also that Naval Constructor Eggert used the method devised by him in connection with the launching of the Washington, which was somewhat earlier than the earliest date mentioned in the paper. I think Mr. Eggert's work deserves recognition, as he is the first, so far as I am aware, to introduce the photographic method of observation. He did not have a moving-picture apparatus at hand, but had to devise modifications of the ordinary hand camera, and to adapt it to the purpose.

I have here a diagram which is not included on Plate 38 of my paper, and which will illustrate the method used to determine the exact point of pivoting. The paper states that the ship commenced to pivot after a travel of 569 feet. That was the point adopted by an examination of the moving-picture film, examined from picture to picture, and confirmed by the same method used here, except that on finally plotting the curve numerical errors were discovered in estimating two points here (indicating on the diagram on blackboard). This is a corrected curve which gives the point at which the ship commenced to pivot, as being after the ship traveled 560 feet. These (indicating) are the tangents of angles, values of .01 to .06. The slope of the ways was 11/16 of an inch to the foot, which corresponds to an angle having a tangent of .057. This (indicating) represents the tangent of the slope of the ways. The position of the ship was examined from the photograph and the angle of trim for different pictures determined.



By plotting all of these points, this (indicating) being a tangent of about .055, you will note that before the ship pivoted (the blocking and cradle were constructed so that the trim of the ship before pivoting was the same as the slope of the ways), and up to the time she commenced to pivot, the tangent of angle of trim of the ship should plot on the line drawn at the value of tangent of the slope of the ways. How near it comes is shown by the observations. This one farthest off represents an angle varying from the slope of the ways by 1/32 inch to the foot. The slope is 11/16 inch to a foot. This (indicating) corresponds to 23/32 inch. The spots plotted here in this direction (indicating) represent the trim after the vessel begins to pivot and the intersection of this line, drawn through the mean location, with the line representing the tangent of the slope of the ways, gives the pivoting point at 560 feet travel.

I have had kindly loaned to me for exhibition here the complete film record of the launching of the Oklahoma. It was hoped to have that film to reproduce the launching for you. It has been forwarded by express, but has not yet arrived. I have brought with me a short section of the film, all that was in my possession, the part which includes all the pictures from which measurements were taken to prepare the data in the paper. I will now show that part. (The portion of the film referred to was projected on the screen as a moving picture.)

Mr. E. C. Bennet (Communicated) :—Relative to the paper entitled "Launching Data for a Battleship," read by Naval Constructor John G. Tawresey, it may add interest to Naval Constructor Tawresey's very instructive contribution to the series of papers upon launching published in the transactions of this Society, to cite the main points wherein the launching arrangements of the battleship Nevada differ from those of the Oklahoma.

The Nevada is the sister ship of the Oklahoma and was built from the same contract plans as issued by the Bureau of Construction and Repair, Navy Department, Washington, so that in all essential particulars both vessels are alike.

The Nevada was launched from the yard of the Fore River Shipbuilding Corporation, Quincy, Mass., on July 11, 1914, and, like those of the Oklahoma, the formalities were entirely successful. For comparative purposes the principal data for the Nevada are given as follows:

Declivity of keel blocks, per foot	10/16 in.
Length of ground ways over all	751 ft. 0 ins.
Length of ground ways submerged	188 ft. 6 ins.
Width of ground ways (each)	60 ins.
Thickness of ground ways	12 ins.
Declivity of ground ways, per foot	10/16 in.
Camber of ground ways	None
Inclination of ground ways, transverse per foot	5/16 in.
Spread of ground ways, center to center	34 ft. 1 in.
Material of ground ways	Yellow pine
Length of sliding ways over all	467 ft.
Length of sliding ways effective	448 ft.
Thickness of sliding ways	12 ins.

Maximum width of sliding ways	56 ins.
Effective width of sliding ways	55 ins.
Bearing area	4,110 sq. ft.
Material of sliding ways	Yellow pine
Length over which poppets distributed pivoting pressure	Plate 39
Number of wedges, spaced, port, 465; starboard, 447.	
Total number of wedges	912
Wedges, oak, about 7 ft. by 6 ins. tapered 11/16 in. per foot.	
Length of forward poppet, about	17 ft.
Length in contact with ways, before launch, about	10 ft. 6 ins.
Total weight on ground ways, tons	11,942
Initial pressure per sq. ft., tons	2.91
Calculated buoyancy at pivoting, tons	8,636
Pressure on fore poppets at pivoting, tons	2,850
Pressure per square foot under fore poppet at pivoting, tons	28.2
Draught, after launching, with cradle, forward	10 ft. 9 ins.
Draught, after launching, with cradle, aft	16 ft. 6 ins.
Depth of water over way ends	9 ft. 10 ins.
Travel before rudder of vessel entered water, about	103 ft.
Distance traveled when cradle entered water, about	172 ft. 3 ins.
Distance from A. P. to after end of ways	215 ft. 3 ins.
Distance traveled when stern began to lift	545 ft.
Maximum speed, per second	23.7 ft.

The vessel was finally held by hard pine sole pieces 56 feet $\times$ 5 feet, 280 square inches sectional area, on each side, with the addition of two dog shores per side of 14 feet $\times$ 14 feet yellow pine. After the dog shores were removed the sole pieces were sawn through for about 112 square inches of sectional area when the vessel tore away without aid from the 50-ton hydraulic jacks provided in case of any sluggishness in starting.

It is considered advisable by the Fore River Shipbuliding Corporation to check the run of vessels after they are water-borne and clear of ways, and, in the case of the Nevada, this was accomplished by the usual method of wooden masks at stern and anchor chains and manila rope stoppers alongside the vessel of which there were 200 of 9-inch manila.

The most interesting difference between the launching arrangements of the two vessels is in the forward poppet. In place of somewhat elaborate rocker used on the Oklahoma we curved or cambered the forward end of fore poppet cribbing for about 6 feet 6 inches of its total length of 17 feet to give a clearance of 6 feet at the forward end, which equals a rocking radius of about 42 feet 6 inches as compared with 50 feet radius of the Oklahoma. Between the rocker and top of sliding ways we introduced white pine 3 inches thick to act as cushion or crushing chocks and distribute any excessive pressure when the stern begins to lift. Unfortunately, we were unable to recover these crushing chocks in a condition that would permit of a true determination of their value for purposes intended.

THE CHAIRMAN:—You have heard Mr. Tawresey's interesting paper, and have seen the reproduction of the photographs taken by moving-picture of the launching of the Okla-

homa. We would be very glad to have any comment. The paper that has been so kindly given us by Mr. Tawresey is of a class which is appreciated particularly by those having to do with the launching of ships. Such papers rarely evoke discussion, and are more in the nature of records of fact. If there is no discussion, I am sure you will be glad to extend your thanks to Mr. Tawresey for his admirable presentation.

If there is no further business, the meeting will stand adjourned until Friday morning at ten o'clock.

THIRD SESSION.

Friday Morning, December 11, 1914.

Mr. Stevenson Taylor called the meeting to order at 10.40 o'clock.

The Chairman:—The Secretary has the names of some new applicants for membership, whose applications have been approved by the Council, to be submitted for your approval.

The Secretary then read the following names:—

For Members (7).

Ellsworth P. Bertholf, Captain Commandant, U. S. Revenue Cutter Service, Washington, D. C.

Edward O. Cutler, Assistant Manager, Craig Shipbuilding Co., Long Beach, Cal.

Carl K. MacFadden, Fuel Oil Engineering Department, Inter-Ocean Oil Co., 90 West Street, New York, N. Y.

W. Selkirk Owen, Assistant Professor, Naval Architecture and Marine Engineering, Webb's Academy, New York, N. Y.

Eugene E. O'Donnell, Supervising Inspector, Steamboat Inspection Service, 39 Dakota St., Dorchester, Mass.

Samuel R. Percy, Shipbuilder, Percy & Small, Bath, Me.

Robert Warriner, Chief Engineer, Fore River Shipbuilding Co., Quincy, Mass.

Associate to Member (2).

Charles E. Ross, Consulting Engineer, 52 Beaver St., New York, N. Y.

Edward Smith, President, American Shipbuilding Co., Cleveland, Ohio.

Associate (2).

F. L. Andrews, General Manager, Hyde Windlass Co., Bath, Me.

Frank S. Masten, Proctor in Admiralty, Rockefeller Building, Cleveland, Ohio.

The Chairman:—Those in favor of the approval of these names please say Aye; contrary-minded, No. The motion is carried. These gentlemen are now members according to the grade announced.

The next business is the report of the committee appointed yesterday to discuss the question raised by Mr. Aldrich. If Mr. Aldrich does not mind, I will read the report. It is as follows:—

"It is beyond dispute that the development of the foreign commerce of a nation such as ours is seriously hampered so long as the carriage of that commerce depends upon the convenience and ability of foreign carriers, nor can it be denied that our nation has been paying tribute to foreign nations to perpetuate such foreign supremacy, to the detriment of individual opportunity and of our established system of wages and conditions of living.

"This Society, which has for its aim the advancement of the art of shipbuilding, takes this opportunity of submitting a recommendation to the President and Congress on the recognized necessity for rehabilitating our foreign service.

"*Resolved,* That the interests of an important industry, involving both capital and labor, can be best served by encouraging shipbuilding in American shipyards and the operation of such ships under the American flag, and that any legislation relating to our merchant marine should recognize and increase the advantage of our nation's general system of industrial development.

"Therefore, it is believed that such additional legislation as may be enacted should have in view the relief of existing burdens and take account of the unquestioned additional cost of operating ships in accordance with the laws and industrial policy of our country.

"To this end, the Society begs to offer its assistance in the consideration of technical matters or in any other way which the President and Congress may deem appropriate."

THE CHAIRMAN:—Gentlemen, what is your pleasure with reference to this resolution?

On motion, the resolution was adopted.

THE CHAIRMAN:—In order to facilitate the programme yesterday one of the papers appearing on the printed schedule to be read to-day, Paper No. 9, entitled "The Thermodynamics of the Marine Oil Engine," by Mr. John F. Wentworth, was read yesterday, and the author thinks some one might be here expecting the paper to be read to-day. He asks me to announce that if any one is interested in the paper and desires to discuss it, he hopes that the discussion in writing will be sent to the Secretary so that he may have an opportunity of replying thereto.

The next paper will be No. 8, "Recent Developments in Submarine Signaling," by Mr. J. B. Millet.

RECENT DEVELOPMENTS IN SUBMARINE SIGNALING.

By J. B. Millet, Esq., Visitor.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

In order that the present state of the art of submarine signaling may be better appreciated, it is necessary to review briefly its origin and growth.

Something over thirty years ago, Professor Tyndall on behalf of the Trinity House, England, supported by a liberal grant from the Government, undertook a very careful, scientific investigation to ascertain why fog signals in the air could not always be heard even at short distances, or, when heard, could not be located with any accuracy. The strandings of vessels on the coast of Great Britain each year amounted to an appalling number, and in a very great majority of cases the officers reported that they had mistaken the direction from which the fog signals came, although they could be heard clearly. There seemed to be something mysterious about the action of sound in the air, more especially when the air was filled with fog. About the same time, Professor Henry was authorized by the United States Government to make a similar study of the problem in America. At the end of their researches these two pre-eminent authorities agreed entirely upon one conclusion, viz., that fog signals in the air were absolutely untrustworthy. There was little satisfaction in this, and navigators as a rule were very loath to accept this conclusion as a definite fact. They were dependent absolutely upon fog bells and fog whistles to guide them when in danger of stranding or colliding, and there was nothing else to do but to continue to trust them as best they could. Trinity House, however, which controls the lighthouse establishments of Great Britain, as is well known, from that time on has warned all navigators not to place implicit confidence upon any air signal that they could not actually see.

It would appear from this that the navigators and the shipping concerns would all gladly accept and investigate any invention which might tend to be a source of relief, but the natural conservatism of those who pass their lives upon the water has prevented them from taking up submarine signaling with anything like the interest which ought naturally to be expected.

It may be a surprise to many to know that, as early as 1883, Prof. Lucian I. Blake, of Kansas, conducted elaborate experiments with sound in water in search of an aid to navigation. He used bells rung under water to create sound, and microphones with which to receive it. He was assisted by the United States lighthouse authorities. In the Lighthouse Board report of 1889 compiled by Arnold Burges Johnson, Chief Clerk of the Board, a complete description of Professor Blake's experiments is given. This was the first attempt made in this country to

ascertain whether sound in water could be used as an aid to navigation. Very soon after this, similar attempts were made in England and then, although the experiments, especially those of Professor Blake, were exceedingly promising, the whole matter was allowed to drop.

In recalling the history of the art it is well to remember, therefore, that as early as 1883 Professor Blake, an American, demonstrated that sound in water could be heard at long distances by ships provided with receiving apparatus. He also contemplated providing ships with some kind of a sound producer. No attempts, however, were made to ascertain the direction from which the sound proceeded, or to work out a practical apparatus.

Even before this, in 1826, Messrs. Colladon and Sturn, on Lake Geneva, had heard a heavy bell rung under water at a distance of ten miles. This was long before the invention of microphones, and their receiving apparatus was much like a cornucopia ear trumpet with a rubber diaphragm stretched across the larger end in order to prevent water from entering it.

Ten years after Professor Blake had finished his experiments, and the momentary interest in his work had died out, Mr. A. J. Mundy, of Boston, having no knowledge whatever that anyone had ever made any attempts to use sound in water for this purpose, conceived the idea and undertook experiments of his own, aided by Prof. Elisha Gray, the eminent inventor. Mr. Mundy took his hint from the fact that as a boy, when in bathing with his head under water, he could hear stones cracked together under water at a very long distance. His earlier experiments, like those of Neale and Smallpage in England fifteen years before, contemplated a microphone receiver such as is used in the telephone as a transmitter, attached to the ship. Experiments proved that the noises made by the machinery on board the ship created so much sound of their own as to make it impossible to hear anything else if the receivers were fastened to the wall of the ship. In an effort to overcome this, Mr. Mundy tried hanging a microphone in a tank filled with water which was attached to the inner skin of a vessel under water. It was found at once that the skin of the ship did not interfere in the least with the passage of sound from the sea outside into the tank inside, and other ship's sounds were largely excluded. The microphone located in the tank picked up the sound and transmitted it by the usual method to any point where it was desired to receive it. From this moment the invention went on apace. Various sizes of tanks were tried, but those finally adopted were about the size of half a beer barrel and were constructed so that one end of them was formed by the skin of the ship. After a great many experiments on the sea in ships of all sizes and in all weathers, it was found that in order to obtain direction it was necessary to have a tank on each side of the ship somewhat forward of the bluff of the bow, and by comparing the intensity of the bell sound on one side of the ship with that on the other the direction was readily ascertained.

Mr. Mundy's sudden illness placed this problem of finding direction on my shoulders, and in solving it I used the steamships of the Metropolitan Line which

ran daily between New York and Boston, passing several lightships which were provided with submarine bells. For an observer to locate a submarine bell within one-eighth of a point when five or ten miles off and going at full speed is no longer regarded as a feat of special interest, but in those early days ships' officers and practical shipping men were amazed at it and appreciated its value, although few would believe it until they made their own tests. Realizing that an accumulation of tests covering a large period properly certified by witnesses would be necessary in order to impress authorities abroad, frequent demonstrations were tried on these steamers for over a year, and their officers made practical use of the apparatus whenever they were in fog. At the end of that time, I was sent abroad to "revolutionize" navigation. The greatest tribute to the invention is to be found in the fact that this actually was accomplished, and in a comparatively short time every large transatlantic steamship company, the British Admiralty, the French and German navies and the navy of the United States all adopted the system, thereby recognizing the importance of the invention.

In brief the system is as follows: Bells having very heavy rims are rung under water either from lightships or attached to bell-buoys (which are operated automatically by the wave motion) or supported on the sea floor by a tripod and operated by electric cable connection with the shore. All these methods have been in successful use for several years. On board ship the transmitters which receive the sound are placed in tanks (one on each side of the vessel well forward, below the waterline) and are connected by wire with the direction indicator, which may be placed in any spot most convenient for the navigator. By comparing the strength of the bell sound on one side of the vessel with that on the other, the direction to the bell may be quickly ascertained, for the comparison may be made by merely turning a switch and the bell will always be found on the side where its sound is louder.

It would be a great pleasure were I able to say that the United States Government or any of the shipping concerns in the United States took up this invention with active interest, but, outside of a few members of the Lighthouse Board, no one in authority paid much attention to it. The fact is that the first great authorities connected with shipping to take any special interest in the invention were the North German Lloyd Steamship Co. of Bremen, the British Admiralty, and Trinity House of England. In the same breath I ought to mention that Capt. James Watt (now retired) of the Cunard Co. had always displayed entire confidence in the invention, and he had frequently reported to his owners that the time would come when navigators would trust the sound in the water and not the sound in the air. Although the invention has now been adopted by all the great steamships which cross the Atlantic Ocean, and many of those on the Pacific Ocean, to the number of over twelve hundred, and although submarine bells are being rung at nearly two hundred points on the Atlantic and Pacific coasts, the shores of the Great Lakes, of Great Britain, and on the Continent, there is a great deal yet to be done before the invention will have reached its complete usefulness. It would seem as if

in the last thirty years, scientists and those who are using the apparatus daily would have found an opportunity to have extended its field, and have analyzed every factor in it, and would have demonstrated to the entire world, with absolute conviction, that safety in the navigator lies in using sound in water; but in developing a system of this sort it is necessary to have ships, and large ones, which can be used at the will of the investigator. It is also necessary to operate bells or other sounding apparatus in the water, and it is clearly to be seen that these are conditions which no private company can possibly meet, and no shipping company is willing to go to the expense of allowing any vessel to be used for this purpose for any length of time. It appears, therefore, as if it will be necessary for some government to conduct exhaustive experiments in order to ascertain how far sound in water can be used, or it never will be done.

To say that collisions between ships at sea in fog need never occur, to say that collisions with icebergs can be avoided by means of submarine signals, to say that the efficiency of submarine boats can be enormously increased by the same apparatus, would of course be to excite comment and to create more or less disbelief that the efficiency of this system extends so far. Nevertheless the above is all true, and has been so frequently demonstrated, that it would seem unnecessary to have to assert its truthfulness were it not for the fact that the possibilities of this art are so little understood.

In order that two vessels approaching each other in fog may be kept apart, it is necessary that they either see or hear each other. It is known that their air signals cannot be trusted. It is also known that sound that comes through the water can be trusted. Consequently, that ships may avoid collision it is only necessary that one should make a sound in the water which the other can hear, or that both should be able to exchange signals under the water.

An early experiment made by the writer in 1895, in Long Island Sound, between two ships approaching each other at full speed, showed conclusively that if a heavy bell were rung in a tank built into the forepeak below the waterline of a moving vessel, other vessels which were approaching it forward of its beam could, if supplied with receiving apparatus, hear this bell and locate the approaching steamer at distances from two to three miles. The bell operated in this experiment was comparatively inefficient, but the principle was demonstrated by this experiment. It was witnessed by the Minister of Marine for Canada and several of the directors of the Allan Line at Montreal. There, however, like other important demonstrations that this art has provided, the subject dropped. A few demonstrations were conducted by the writer for the British Government a year later, but that was all. It was recognized that some sort of a sound producer which would create a sound strong enough to carry a great many miles above all other noises in the water was necessary in order to make this particular feature of the invention practical. A large number of experiments have been tried with various kinds of apparatus, and large sums have been spent in the last ten years or more, but nothing practical was found until Prof. Reginald A. Fessenden invented

the "oscillator." This appears to be the last word on submarine signaling, and it it is of immense importance, for it opens the door to a field which is filled with extremely important possibilities. Without going into a detailed description of the oscillator, it is necessary to say that it consists of a very large and heavy diaphragm vibrated under water by an electric mechanism with sufficient force and frequency to generate waves of sound of tremendous power. As these vibrations may be stopped and started at any time by the pressing of a button, it becomes evident that the Morse alphabet may be used for the purpose of sending signals. The device which the submarine signal company has used in their demonstrations is a very large and heavy apparatus weighing eight hundred and fifty pounds. In ordinary experiments it is suspended in the water, but when installed for use on board ship it would be supported against the inside wall of the ship or form a part of it. During tests in Boston Harbor it was found that the oscillator telegraphic signals could be distinctly heard through the water for a little over thirty miles, which of course is far in excess of any distance recorded for the transmission of bell sounds. A more important point, however, to be realized is that this is by no means the limit of distance. Unquestionably oscillators could be built which would transmit a sound much farther than that. We may imagine, therefore, that if steamships traversing the seas are provided with oscillators which can send out under-water signals as warnings to vessels from twenty-five to thirty miles away, navigation in fog would lose its terrors. The oscillator was thus intended to provide the much needed sound producer, but it has been found that it is a very efficient sound receiver as well. In other words, the apparatus which creates sound under water may be used to receive sounds. It has, in fact, certain distinct advantages over the ordinary telephonic receiver such as is now being used on ships, which are as follows: The granular transmitter, when shaken or agitated in any way (as by the jar of a ship's machinery), transmits disturbing sounds. Anyone who uses the telephone has noticed such foreign sounds. These sounds when transmitted on board ship are classed as "ships' noises." They frequently interfere seriously with hearing sound signals coming through the water, and one of the great problems that this invention has tried to solve has been to "cut out ships' noises" in order to give the sound signals in the water the best opportunity to be heard; consequently it has sometimes happened that ships have been obliged to slow down or even to stop in order to get under-water signals at long distances. Professor Fessenden's oscillator, however, when used as a receiver, by reason of its construction, can not pick up any sounds which originate within itself, and it does not hear any of the sounds which come to it through the air or through the ship's hull, consequently it should be, when carried to its limits of sensitiveness, a more efficient apparatus for receiving submarine signals than the granular transmitter which is now in common use.

It is safe to say, therefore, that this invention provides navigators with the one apparatus needed to complete the system when used for the avoiding of collisions between ships at sea.

Various kinds of apparatus for detecting the presence of icebergs at sea have

been invented. All of them depend either upon the transmission of sound in the air or upon observations in temperature, and none are trustworthy. Experiments made by Professor Fessenden in the North Atlantic on board the United States revenue cutter Miami, have proven quite conclusively, however, that the presence of icebergs may be detected by operating an oscillator on board ship in such a way as to send out a powerful sound wave under water, and then observing the time and direction from which echoes are returned. An authoritative account of this experiment is given by Captain Quinan as follows:

"We stopped near the largest berg, and by range-finder and sextant computed it to be 450 feet long and 130 feet high. Although we had gotten within 150 yards of the perpendicular face of this berg and obtained no echo from the steam whistle, Professor Fessenden and Mr. Blake, representatives of the Submarine Signal Company, obtained satisfactory results with the submarine electric oscillator placed ten feet below the surface, getting distinct echoes from the berg at various distances, from one-half mile to two and one-half miles. These echoes were not only heard through the receivers of the oscillator in the wireless room, but were plainly heard by the officers in the wardroom and engine-room storeroom below the waterline. Sound is said to travel at the rate of 4,400 feet per second in water. The distance of the ship, as shown by the echoes with stop-watch, correspond with the distance of the ship as determined by range-finder."

It may be noticed that any ship which is equipped with the oscillator for ordinary purposes of navigation is at the same time provided with all that is necessary to obtain the same results in detecting the presence of icebergs that Professor Fessenden and Mr. Blake secured.

The value of the submarine in war is now being tried out practically for the first time. The British and the German navies are both thoroughly equipped with this arm. Whether Sir Percy Scott is right in giving the submarines a greater importance as a fighting arm than the dreadnoughts may be determined in the next few months. Whether it is or not, there is no question whatever that the recent improvements in submarine signaling will make the submarine a much more efficient instrument in warfare.

The receiving apparatus now in common use consists, as has been stated, of a granular transmitter which hears everything that comes to it, whether it be a noise on board ship or a jar of any kind which disturbs the granules in the transmitter, or a noise coming through the water. Professor Fessenden's oscillator, however, when used as a receiving instrument, hears nothing of the noises on board ship, consequently we may imagine a submarine boat fitted out with two ears, one on each side well forward with which to pick up any sounds that may come to it through the water, and which will not be disturbed by any of the noises made inside the craft. Thus provided, a submarine boat could stalk a battleship or a destroyer by listening to the noises which come to it. In fact this may be done now by

using the granular transmitter properly installed. Pumps, or dynamos, or some machinery which makes a very considerable noise, are always operating on big ships, and, if it is possible to hear them, an observer on a submarine boat could quickly locate them. I have often heard sounds of this sort many miles through an ordinary granular transmitter, and on one occasion on the Baltic, running at half speed, detected and located a passing steamer several miles off in fog by listening to the sound of her screws. Provided with ears of this sort, a submarine boat could get its orders by under-water signal from its mother ship, could be recalled if desired, or warned, and, by using the oscillator as a signaling apparatus, could also give signals of her own. She could call for help, locate her position, or state anything she wanted to state by using the Morse system.

Since I know all this to be true, I am convinced that this new invention will bring to the submarine boat these tremendously important additional new features of efficiency, and it seems to me that one of the most important duties of the Navy Department of the United States now is to take charge of experiments with this oscillator, to conduct them themselves at the expense of the government, and to find out, before any other country does, how far this new invention can be made an important factor in our navy.

DISCUSSION.

In connection with the presentation of his paper, Mr. Millet said:—

"The apparatus calls for no particular scientific knowledge and no great experience. One of the things that has impressed me most about it in many years' experience with it and in developing its use, is the fact that after it was used by people who were not navigators, who had no knowledge of navigation, but who had been told all they had to do was to listen to the receiver on one side of the ship and compare the sound with that on the other side of the ship, they could then determine with considerable accuracy the location of the sound. I remember the case of a ship going into Boston Harbor in fog. They were trying to pick up the lightship. The captain was on the bridge, it was quite a thick fog, and his wife went to the apparatus and used it and told him where the lightship was. It would seem that one of the great features of an apparatus of this sort is that it does not require any special experience to use it with efficiency. The more one uses it and becomes acquainted with the sounds on his own ship the more expert he becomes in the use of the apparatus. It can be compared to the wireless telegraph system. The first time you put a wireless apparatus to your head you do not recognize all the sounds, if any of them, but sooner or later you do pick out what you want to hear. With the submarine bell, if you are within a reasonable range of the bell, you will hear something that sounds like a bell; and, as a rule, unless the sound of the bell passes through some portion of the structure of the ship, you will hear a musical note. If it is aft, for example, whereas the apparatus is well forward, you might not get any musical vibration.

"I assume that you gentlemen have read the paper sufficiently to know that the apparatus consists principally of two tanks, one on the starboard side and one on the port side, located well forward of the bluff of the bow, so as to present ears forward of the ship, as our own ears are presented forward. In order to ascertain the direction, as I am speaking to you now, you turn your head more or less in order to get the direction of sound, and what happens is that your face makes a sound shadow receiving surface for the ears, and the same principle is applied in the case of the signaling system on board ship. The starboard tank has a transmitter in it connected by wire to the chart room, or wherever desired, and the port tank also has a similar transmitter. These are carbon transmitters, similar to what you speak through in the ordinary telephone system, and therefore as they receive everything that comes to them, practically—if you want to ascertain the direction from which any sound is received—all you have to do is to turn the switch from starboard to larboard, and find out by comparing the sound of the bell on one side with the other. If the ship is directed straight on to the mark the sound will be equally loud on each side. Very frequently it has been possible to detect the direction within one-eighth of a point. It is assumed, in the case of such a fine distinction, that you must have had a little experience in the use of the apparatus so as to be able to absolutely direct your mind to what you are doing. Unfortunately I have been obliged in many cases, in conducting tests for other governments, to call the attention of the men in the chart house to the fact that it would not be considered fair, if you are out on the bridge making this test, that everybody should talk and smoke and shout and whistle. Very frequently the observers who are appointed to report on these tests with me would not stop their conversation, and therefore it required the apparatus to give a more distinct signal than otherwise would be expected. I think that is all I have to say on the subject, and I shall be glad to answer any questions which may be asked."

THE CHAIRMAN:—There is another paper on this same subject, No. 15, "Submarine Signaling and a Proposed Method of Safe Navigation in Fogs," by Commander F. L. Sawyer, U. S. N. Before we take up the discussion on the paper by Mr. Millet, I will ask Commander Sawyer to present his paper.

Commander Sawyer presented the paper, and in connection with its presentation made the following remarks:—

Referring to the plates, Figs. A and B, Plates 52 and 53, are presented to illustrate a number of typical cases explanatory of the system. Fig. A shows two vessels "A" and "B" each steaming 15 knots and 5 miles apart when the distance is first measured. Vessel "A" is on course East (90°). Take the first case when vessel "B" is assumed to be steering West 270°, or directly opposite the course of "A." In order to collide, "B" would have to be on the same line representing "A's" course. In that case they would be approaching each other at the combined speed of 15 knots each or 30 knots, one mile every two minutes. As they are 5 miles apart collision would then occur in ten minutes. Referring to Fig. B this line is shown as the collision line marked 270°, a straight line because the bearing does not change, cutting the time scale at ten minutes. The distance actually measured would in the illustration fall upon the curved line 270° shown in Fig. B and the operator on watch would know at once that the vessels were changing bearing rapidly and no collision could occur. Fig. B shows that at the time collision would happen the vessels are actually 3.8 miles apart and separating.

SUBMARINE SIGNALING AND A PROPOSED METHOD OF SAFE NAVIGATION IN FOG.

By Commander F. L. Sawyer, U. S. N., Member.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

The subject of safety at sea is of vital importance in all questions of design and handling of vessels, and the methods for prevention of loss of life and property at sea has at least as great an interest to this Society as has the question of minimizing the effect of collision or wreck by subdivision, extra boats and other remedial measures after the accident has taken place.

The purpose of this paper is to present a proposed method of avoiding collision when navigating in fogs.

It is unnecessary to emphasize the great danger which constantly confronts the navigator handling a vessel at sea in foggy weather.

All who have actually had the experience of handling vessels at sea realize that at the present day the largest and safest vessels under all other conditions become an ever-present danger to themselves and others the moment fog is encountered. A certainty of safety no longer exists. A chance of disaster impossible to avoid is ever lurking in the impenetrable fog in which the vessel finds itself immersed.

Of all the perils of the sea, fog is by far the greatest remaining unconquered. Storms have largely lost their terrors due to the size and staunchness of modern vessels. Rocks and shoals are generally well surveyed and charted the world over. Lighthouses and lightships guard the coasts.

Fire has lost most of its former dangers due to steel hulls, watertight compartments, efficient fire apparatus and the use of electricity for lighting.

Danger from icebergs is confined to a small area of the ocean. Accidents from this cause have heretofore been comparatively rare, and this danger is now minimized by the establishment of the Ice Patrol.

Danger from fog has, however, continuously increased. The loss in vessels during the ten years' period from 1893 to 1902 has been stated to have reached 1,000, approximately two each week, with loss of over $57,000,000 in property and 530 lives during the same period. During the present year, among the many losses due to fog, all will recall that on our own coast the Monroe was sunk by the Nantucket with the loss of 41 lives, and the Empress of Ireland was lost with 1,033 lives in the St. Lawrence, the latter involving loss of life two-thirds as great as that sustained by the Titanic disaster.

Danger of collision in fogs has greatly increased in recent years on account of the great increase in both the size and speed of vessels.

The inexorable law of energy being proportional to the product of the mass multiplied by the square of the velocity unfortunately applies equally to ships and to projectiles, and the energy of the 55,000 tons of the Titanic at a speed of 21 knots equalled the striking energy of forty 12-inch shells.

The sole means of avoiding collision in a fog at the present time is that prescribed by the "Rules of the Road," viz., the fog whistle or siren. So far as range, efficiency and reliability are concerned, the fog signals of the Olympic, Imperator or Wyoming have made no appreciable advance since our largest men-of-war used steam as auxiliary to sail power. Fog navigation is still in the dark ages, and in this field science has found itself literally "befogged."

A system of handling vessels in a fog, which for want of anything better may be said to have worked fairly well with sailing vessels and low-powered steamers of small size and low speed, has under present-day conditions broken down.

The rules of the road have evaded a definite law prescribing and defining the term "moderate speed." This definition has been left to admiralty courts to interpret, but always after the collision.

An examination of some of the decisions is illuminating. H. Stuart Moore in the "Rules of the Road at Sea" cites numerous decisions as, for example, in the English Channel 3½ to 4 miles per hour was held to be immoderate, and 200 miles east of Sandy Hook the courts have held that 7 knots exceeded the speed limit.

In January, 1914, the Navy Department by general order called the attention of the Naval Service to the subject of speed in a fog, referring to the text-book on seamanship by Admiral Knight. In discussing the handling of a ship in fog this text-book states:—"An officer hearing the fog signal of a vessel which he cannot see can usually form a general idea of its bearing and may be able to judge something of its distance, but even with regard to these points there is danger of serious error, and of all other points he is absolutely ignorant. * * * A steamer's whistle can be heard, under favorable circumstances, two miles or more, * * * but so many things affect the question of audibility that it is not safe to rely upon hearing it more than, say, half a mile, even when all conditions seem to be favorable."

The standard turning circle used in our fleet is half a mile in diameter.

The classic investigations of Tyndall in sound demonstrated that air is unreliable and, indeed, frequently erratic as a sound conveyer. Refraction and other causes often produce zones of silence near the source of sound. In the course of his investigations for the British Government in 1874, conducted near Dover in the English Channel, he found that the intensities of fog whistles, sirens and gunfire were fifty times greater in some conditions as in other instances observed, and the poorest results were obtained when conditions were apparently favorable. These conclusions are confirmed by the experience of seagoing men; where some-

times at short distances the jets of a steam whistle are counted, yet the sound is not heard.

These facts force us to the conclusion that present methods of navigating vessels in a fog are totally inadequate to insure reasonable security to life and property, and that danger always exists, which the skill of the personnel cannot eliminate. The recent collisions between the S. S. New York and Pretoria and between the S. S. Kaiser Wilhelm II and Incemore are still fresh in the public mind. There seems to be no evidence to show that these large passenger vessels were inefficiently handled. The reason that collisions are not even more frequent is due solely to the fact that the oceans are vast and ships at sea so widely scattered that by chance they usually have plenty of sea room.

Fortunately, investigations have shown that water, unlike air, is an excellent sound medium, and does not appear to suffer from the acoustic clouds and erratic reflections found in air by Tyndall.

A brief history of submarine sound signals indicates that investigations to determine the uniform character of water as a sound medium have not been carried out with the thoroughness of similar experiments in air, and still present a fertile field for scientific cultivation.

The results of experience demonstrate that the density, homogeneity and elasticity of water render it many times more efficient than air in transmitting the pressure waves of sound.

Primitive man doubtless used some crude methods of submarine signaling, and from time immemorial Cingalese fishermen have used code signals by striking an earthen bowl held submerged outside their fishing boats. The sound would be heard by placing the ear against the hull of another boat miles distant.

It has long been a matter of common knowledge that sound would pass through water for considerable distances, and that an observer stationed below the waterline could hear the sound after it had passed through the side of the vessel.

The classic experiments of two scientists, Colladon and Sturm, conducted in Lake Geneva in 1826, furnished the most exhaustive and complete data of the early investigators in sound transmission through water. They employed for this purpose a large submerged bell, and received the sound through a very large and specially constructed ear trumpet. A flame upon the end of the lever which caused the bell to ring simultaneously ignited gunpowder, and the elapsed time from the instantaneous flash and the reception of the sound measured its velocity. These experimenters found that the sound could be transmitted entirely across Lake Geneva, a range of 32 kilometers being obtained. The velocity of sound was determined with reasonable accuracy, and found to be 4,708 feet per second. They also discovered that the bell tone as ordinarily understood decreases with remarkable rapidity in water, so that after a few hundred yards only a percussive click could be distinguished. Colladon likened this sound very aptly to that made by the back of two knife blades when struck together. All who are familiar with the use of the submarine bell in navigation will recognize the description of the sound. Observers

who have never heard a submarine bell would, unless instructed, never identify this dull, instantaneous click for the bell sound that experience in air sounds would naturally lead them to expect.

The knowledge of the efficiency of water as a sound medium had existed for a very long time before any successful application was made for navigational purposes. The inherent difficulties of receiving the sound on board of a vessel under way due to interference from ship noises, and of transmitting submarine signals from vessels under way, prevented its practical use. Over fifty years had elapsed from the experiments of Colladon and Sturm to the date when the first patent issued on the application of the principle of water signaling. The discovery of the telephone had not improbably turned attention to its utilization for this purpose. A patent was issued to Mr. Henry Edmunds in 1878. He proposed the use of a bell or gong for sending, and a telephone for receiving. Among the numerous inventors who have since applied themselves to the subject is the name of Thomas A. Edison.

The development of submarine signaling, which finally resulted in successful commercial application, began in 1898. Mr. A. J. Mundy, of Boston, collaborating with Professor Elisha Gray, carried on continuous experiments up to the death of the latter in 1901, at which time after three years, although much data had been obtained, the problem was still unsolved.

No sending apparatus had been discovered which could be installed in a moving vessel, and no receiver had been developed which was not rendered useless with a ship under way on account of the noises of the ship and water rushes. The complete problem demands an apparatus for sending from a ship under way, and receiving the message on a ship under way. A solution of the latter was discovered by Mr. Mundy. He found that a sound wave traveling through water would pass through a steel plate immersed in the water without serious diminution, and that therefore the sound waves could be heard within a compartment of a vessel if filled with water. A microphone immersed in water intercepted the distant sound signal, and at the same time was not sufficiently affected by the water rushes and foreign noises to prevent the reception of the distant sound wave traveling from the bell. By designing receiving tanks filled with water in which the microphone was immersed, it was finally found that a tank 18 inches deep and 16 inches square was sufficiently large for the purpose, and the present commercial type is of the above size shown installed in Fig. 1, Plate 45.

The submarine bell designed after many experiments is that shown in Fig. 2, Plate 45. The marked difference in cross-section with a bell to be sounded in air is notable. Vibrations of 1,215 per second were adopted for efficient range and audibility.

The development of a satisfactory signal system, at least for naval purposes, requires that the signals be sent equally well in all directions and that they be received with equal facility from all directions.

The ideal intensity curve of a sending system and the audibility curve of a re-

ceiving system should, then, be circles. The bell probably fulfils this condition, due to the fact that when struck it divides into four vibrating segments separated by four nodal lines. These vibrations are illustrated in Fig. 3, Plate 45.

The receiving apparatus shown in Fig. 1 is defective in respect to its arc of receiving sounds being restricted. The greatest range is obtained when the sound wave is normal to the plate. As the angle of incidence becomes more acute the range diminishes probably nearly in proportion to the projected area. Complete data on this point have apparently not been obtained. This deficiency is utilized in the commercial application of the receiving tank. By the use of two tanks, one on either bow of a vessel, and by listening to the microphone on either bow successively, it is possible to ascertain on which side of the observing vessel the signal is heard, or appears more intense. The direction of the bell or sending device can then be approximately ascertained by altering the course of the vessel until the signals appear equally intense. The signaling station should then bear ahead if the microphones are equally sensitive and the observer sufficiently skilful in estimating the relative intensity of the sound. Fig. 4, Plate 45, illustrates the audibility curve of an average vessel. The actual range is greater when stopped than when under way, and is naturally better in a calm sea, due to absence of rolling and pitching.

The commercial adoption of the submarine receiving tanks and the installation of submarine bells upon lightships have unquestionably been of immense value in saving life and property, and one of the greatest steps ever taken in advancing safety at sea. At the present time nearly 100 bells are in operation on many coasts, and over 1,000 vessels are equipped to receive their signals.

While the value of this aid to navigation in fogs cannot be overestimated, it has unfortunately covered only a part of the field necessary in safe fog navigation. Vessels equipped only with receivers are as helpless to avoid collision as before their installation. A vessel crossing the North Atlantic is exposed to collision in case of fog during any part of her 3,000 miles cruise, while the receivers would only be used during the few miles in passing the lightships.

The problem of safety in fogs involves at least, as one feature, communication between ships. The bell for many reasons has never been adopted on seagoing vessels.

The next great step in advance in the art of submarine signaling was made by an Austro-Hungarian physicist, Mr. H. Christian Berger, who realized the necessity for an efficient means of submarine signaling between moving vessels to secure greater safety in fogs, and devoted his talents to the solution of the problem.

The problem was a difficult one, as great power is required to compress water sufficiently to set up the intense pressure waves requisite for radiating the required distance. His investigations led him to adopt the principle of longitudinal vibrations set up in a steel wire or strip set into vibration by frictional means.

His first test was made in the river Danube near Budapest in 1910.

In August, 1911, by using a piano wire of only 2 millimeters diameter set into

longitudinal vibration by a hand-driven silk wheel moistened with alcohol, the wire being fastened to the iron hull of a small tug, he was able to read signals 2.8 kilometers distant. It is interesting to note in this connection that during the siege of Paris in 1871, the French endeavored to communicate by means of a submerged bell in the Seine but were unable to reach 2 kilometers, from which failure the French physicist Lucas concluded that submarine signals were incapable of transmission in rivers. Fig. 5, Plate 46, shows the wire as used in the experiments on the Danube.

The secret of the extraordinary efficiency of this system lies in the fact that the vibrations used are longitudinal and the stresses molecular. Unlike a plucked violin string, where the pitch depends on the tension, the pitch in longitudinal vibrations is independent of its tension. As friction is always rythmic the exciter throws the wire into intense longitudinal oscillations, and a clear and absolutely uniform musical note is generated in the water. In order to produce a note of 1,000 vibrations per second most suitable for microphones, the wire is cut for one-half a wave-length. As the velocity of sound in steel is about 16,000 feet per second, the wire would be one two-thousandth, or about 8 feet in length, and this would generate a sound wave of about 4.7 feet in the water. Wide limits are practicable, and the most efficient wave-length for submarine signals has not yet been determined.

An efficient submarine signal system is urgently needed for submarines. Our navy had begun to equip with a submarine bell mounted outside the hull, but the dull "click" of a submarine bell did not lend itself to Morse signals. The clear musical note emitted by the Berger apparatus possessed the valuable quality of an easily distinguishable and sustained note, capable of being sent in dots and dashes of the Morse code. The sound has the qualities of the aerial wireless, and it has therefore been called submarine wireless.

On August 4, 1912, U. S. Submarine E-1 was equipped with the identical wire and exciter used in the Danube experiments, and readable signals were transmitted and received over a range of 2 knots off Newport, R. I. The same month another experiment was made by the submarines off Provincetown, using the same silk wheel exciter but substituting a wire of 4 millimeters diameter. Messages were received over a range of 4 miles.

The results of these tests were so encouraging that a larger apparatus was next constructed, using a half horse-power motor to drive the exciter, and the size of the wire was increased to a flat steel strip having a thickness of $\frac{1}{16}$ inch and a width of ½ inch.

The apparatus is shown in Fig. 6, Plate 47. A commercial type of Morse key not shown operated the magnetic clutch shown on the motor shaft, and by this means Morse signals were generated by starting and stopping the felt wheel which in operation presses the steel ribbon, not shown in the figure. A test of this set installed on the Submarine E-1 was made in December, 1912, off Hampton Roads. Readable messages were sent and received for several hours at various distances while the E-1 was under way and submerged. A range of 7.8 knots was obtained

on that day, and at a distance of 6 miles while still invisible from the U. S. S. Castine, the E-1 rose to the surface and signaled the maneuver by this apparatus.

A still larger set was next constructed using a 3 horse-power motor to drive the exciter, and three ribbons each 1½ inches in width and $\frac{1}{16}$ inch in thickness. The set was designed to be installed upon the U. S. S. Arkansas for test purposes and is shown in Fig. 7, Plate 48. The frame here shown is necessary to anchor the wires, as the beam of the ship at the place selected for installation was about 24 feet and it was believed that a wire of that length with a pitch of about 300 vibrations per second might not give as good results. The riveted plate shown in the figure represents the side of the vessel, and as installed the thickness of the plate and side of the vessel was made 2¼ inches. Tests recently made between the U. S. S. Arkansas and Utah showed the apparatus gave distinct signals at over 10 knots' range. The side of the Arkansas, where used as a diaphragm, consisted of three thicknesses of plate riveted together, and was in no degree attuned to the vibratory period of the wire. It is probable that diaphragms fitted to the system would yield much better results, though those obtained are sufficiently remarkable to demonstrate the efficiency of the method.

Shortly after the government's tests on the submarines had demonstrated the possibilities of the Berger apparatus to send Morse code signals under water, Professor R. A. Fessenden, whose name is already well known in the aerial wireless field, turned his attention to the development of an all-electrical apparatus for submarine wireless. Efforts had previously been made in England and Germany along this line, particularly by Evershed in England. The device which he designed is termed an "oscillator" and is shown in Figs. 8 and 9, Plate 49, and consists essentially of a massive ring magnet, "A," energized by the coil "C" producing an extremely intense magnetic flux which flows from one pole of the ring magnet across the air gap into the central stationary armature "D," thence across the lower air gap to the lower pole face of the ring magnet, thence through the yoke of the pole magnet back to the upper pole face. Lying in this air gap is the light moving copper tube "A." The stationary armature "D" carries a fixed winding one-half clockwise and the other counter clockwise.

An alternating current is fed to this armature winding and induces another alternating current in the copper tube of about 10,000 amperes. As the copper tube lies in a field having an intensity of about 15,000 lines of force per square centimeter very strong forces are created and the light copper tube is driven back and forth 1,000 times per second with a force equivalent to a pressure of two tons. By attaching the shaft to a diaphragm in contact with the water these intense forces are transmitted to the water in compressional waves 500 times per second, giving a wave-length of a little more than 9 feet, which is heard as a clear musical note. An interesting feature of this oscillator is that when acted upon by sound waves it acts as a receiver, and is in effect either a reciprocating generator or motor. The 5-kilowatt oscillator weighs 1,200 pounds and the diaphragm has a diameter of about 2 feet.

This apparatus was tested by the inventor in Boston Bay, and was heard at a distance of 31 knots when suspended in open water from the Boston lightship at a depth of 12 feet.

The first tests of the oscillator on board the submarines were not successful in reaching more than half a mile, this lack of efficiency being attributed to the fact that the hull was used as a diaphragm by connecting the oscillator thereto instead of installing an attuned diaphragm. Afterwards four sets each were installed upon the Delaware and Wyoming, the hull likewise being used as a diaphragm. With these vessels a maximum range of three miles was attained in the final tests as reported in October, 1913.

In July, 1914, two sets were mounted on submarines K-1 and K-2 outside the hull of the vessel, by securing them to the superstructure deck facing forward. The results of the tests made off Newport, R. I., gave a readable maximum range of 6 knots, with a minimum range of 2 knots except when the sound shadow of the conning-tower interfered.

On the recent tests made by the U. S. S. Arkansas and Utah, the former carried a 5-kilowatt oscillator suspended in the water from the boat crane, using 25 feet submergence, while another set was mounted with a tuned diaphragm riveted to the hull of the Utah. A maximum range of 10 knots was obtained in this test made on November 7, 1914.

The oscillators were used both for sending and receiving, and by the use of a Morse key the speed was equal to that of the aerial wireless.

The difficulties yet to be overcome for an all-round submarine signal system are:—

1. To attain an equal radius in all directions for sending. All systems using a diaphragm are directed.

2. To attain an equal audibility in all directions for receiving.

3. To eliminate the sound shadows caused by the vessel itself and the effect of the wake.

Unless these deficiencies can be overcome, submarine signals will not be entirely satisfactory for naval purposes.

The same defects are undesirable for fog navigation but not vital, and an arc of audibility somewhat greater than the 20 points of visibility required for the running lights of a vessel would, if necessary, suffice for safety.

Many who are not skilled in navigating or handling vessels might naturally assume that with a satisfactory means of submarine signaling between vessels under way capable of reaching 3 to 5 miles, the whole problem of safe fog navigation would be solved. This, however, is unfortunately far from being the case.

Vessels under way equipped with an efficient system of submarine wireless would be able to hear each other's signals farther than the average range of the steam whistle and would be able to signal their speed and course. They would also be enabled to ascertain on which side of the vessel the signals were received by means of the microphones and receiving sets already shown or by analogous methods.

Any attempt to obtain a definite bearing would require the vessels to change course and head for each other, a maneuver decidedly objectionable and dangerous. In fact most collisions at present occur after the steam whistles are heard while maneuvering to avoid each other.

Even if we assume that handling two vessels in a fog by heading for each other is permissible, the accuracy of the result would depend, first, upon the receivers having the same sensitiveness, and, second, the judgment of the observer in comparing them. In practice microphones are rarely found alike, and the same set varies from day to day. It has also been suggested that the loudness of the sound could be used as a measure of the distance between the vessels. Experience in submarine signaling demonstrates that the intensity of the sound received depends not only upon the distance but also upon the angle it strikes the outer plate of the receiving tank, the speed of the vessel, the state of the sea, the condition of the microphones, the rolling and pitching of the vessel, and probably also upon the state of the water itself. A practical mariner would hardly trust the safety of his ship to an equation with so many variables. The submarine signal furnishes a necessary element in the problem of fog navigation, but is not in itself sufficient to secure safety.

For many years since the advent of wireless, efforts have been directed to its use as the solution of fog navigation. On shore the installation of the umbrella type of directional aerials has been attempted where signals are transmitted over each wire in turn arranged radially. The relative strength of the signal is used to determine the direction. A modification for shipboard of two directive aerials at right angles to each other and an instrument called a radio goniometer have been used to determine the bearing of the sending station. This radio "angle measurer" is rotated to the point where the received signal is most intense, thus indicating the bearing of the sending station or vessel.

Vessels equipped with directive aerials and the radio goniometer could therefore communicate to each other in a fog their courses and speeds, and, so far as the accuracy of the instrument permits, gain an idea of their relative bearings.

The deficiencies of this method alone for securing safety in fogs are not unlike those of the submarine wireless. No definite information of the distance between vessels is obtained as the intensity of the signal depends upon numerous variable conditions, and the accuracy of the bearing depends upon the judgment of the observer as to the relative intensity of the signals. While possibly capable of accuracy when tested by a skilled observer in a laboratory, the fact that the intensity is not sharply defined but follows the sinusoidal curve would cause the practical navigator to mistrust its use as a sole dependable means of safety. Neither the submarine wireless alone nor the directive aerial wireless alone is sufficient. In case a choice were to be made between the two, the directed wireless would probably be preferred, on account of its more reliable range and the ability to determine the approximate bearing without altering the course of the vessel.

The U. S. Naval Institute in its last quarterly publication contains an interest-

ing article by Captain Armistead Rust, U. S. N., on the subject of "Safety at Sea." He proposed in effect steamer lanes which must be adhered to in fogs, extra slow speed where such lanes cross, and a code signal of six letters or numbers to indicate latitude, longitude, course and speed.

There is no doubt that a close adherence to steamer lanes in fogs would reduce the chances of collision.

None of the above systems would, however, be sufficient in the opinion of the author to meet satisfactorily the urgent demand for safety and fill the requirements of the practical mariner.

The ideal conditions would be met if the elements necessary in handling the vessel when both are clearly visible were equally available in a fog. The following proposed method is submitted as a solution of the problem.

Before proceeding to its description, although perhaps scarcely necessary, it may make the system clearer to briefly review the customary method of handling two vessels in sight of each other as prescribed by the "Rules of the Road."

The officer of the watch while still distant takes a bearing of the other vessel, and observes closely whether the bearing changes. If the bearing does not change the vessels would arrive at the point of crossing at the same instant and collision would occur. If the bearing changes the vessel hauling ahead will arrive at the crossing first and the other hauling aft will pass astern.

In this case the element of relative bearing is known accurately, and the distance is not accurately known, but must be ample to permit of successive bearings being taken with sea room remaining to maneuver if necessary. An experienced seaman is usually able to estimate the latter.

A satisfactory system of fog navigation would require:—

(*a*) The presence of another vessel to be ascertained at least as far as the steamer lights are visible, namely, 5 miles.

(*b*) A knowledge of the course and speed of the other vessel.

(*c*) Information as to whether or not the bearing of the other vessel is changing, without changing the speed and course of either vessel.

(*d*) Ample sea room to change course in case such maneuver is found necessary.

(*e*) Simple means and apparatus involving no calculations or estimates to be made so that an intelligent enlisted man can carry out the method.

In order to accomplish the above the method proposed contemplates the use of the simplest form of wireless with any efficient form of submarine wireless.

In case of fog, simultaneous signals are sent from a vessel, and instead of the six characters mentioned above only a single letter or number in the Morse code is necessary to be sent. The 26 letters and 10 numbers each represent 10 degrees of the compass, so that any course is signaled to the nearest 5 degrees, with an average error of less than one-quarter of a point. The observer, using an ordinary double head-piece receiver on another vessel, receives the wireless signal and submarine wireless signal, but not simultaneously, as the former is instantaneous while the latter, at 5 miles' distance, for example, arrives more than six seconds later.

This very considerable interval renders it easy to measure the distance between vessels with greater accuracy than necessary for purposes of navigation.

After arriving within range of the submarine wireless signal, the vessels are able to know at all times their distance within an error that should not exceed 300 yards.

Figure 10, Plate 49, shows diagrammatically the apparatus used for sending.

A shaft (75) is rotated by a clock or uniform speed motor one revolution per second. This carries a wheel (74), which is shifted along the shaft according to the speed from 6 knots to 30 knots, and this wheel meshes into the spur gear shown having the number of teeth corresponding to the speed in knots. A complete revolution of one of the spur wheels releases the cam cylinder (51), on the surface of which are cut the Morse characters corresponding to the courses. When this cylinder revolves the cams pass under the two keys of the wireless and submarine wireless adjusted to cause simultaneous signals to be sent. These keys are adjusted for the course of the vessel.

A vessel, course north, at 10 knots therefore automatically signals the letter "A" every 10 seconds. A vessel running into a fog would have only to throw the switch to signal her course and speed, and any vessel hearing the above letter would know her course and after one or more repetitions would be informed of her speed. As soon as the submarine signal is heard the successive distances separating the vessels are constantly obtained.

The instrument for graphically measuring this distance is shown in Fig. 11, Plate 50.

The horizontal shaft is the same as shown in Fig. 10, rotating uniformly one revolution per second. The observer hearing both signals has only to press the Morse key (130) on receipt of the wireless and release the key on receipt of the submarine signal. By operating a solenoid the horizontal lines are generated as shown on the traveling sheet which is graduated in miles and tenths, or 200 yards. It is thus easy to keep constantly informed of the speed, course and distance of any vessel within the radius of the submarine signal. It might appear that this information is all that is necessary in navigating through fogs, but a great deal more is required by the practical seaman who naturally preserves his speed and course wherever possible, and who wishes to know whether or not his bearing is changing. Fortunately, a method is now available for giving him this vitally needed information in ample time to avoid collision, and where he is able in most cases to proceed without change of speed or course, with positive information in no wise dependent on the judgment of the lookout as to maximum sound direction.

In Fig. 12, Plate 51, is shown a simple instrument consisting of four jointed straight edges graduated in knots and tenths. To explain its use it should be remembered that when two ships are under way with uniform course and speed, at any particular time there is only one bearing combined with one distance which would cause collision.

Referring to Fig. 12, assume that both vessels are at the center 140. This construction was adopted to simplify an otherwise awkward construction. Assume the course and speed of the first vessel to be (145), and that of the second vessel to be (146). If collision were to occur the second vessel would then actually be at (144). The rate at which the vessels would approach to collide would be 140–144, which is conveniently ascertained by swinging one of the graduated arms 175 or 176 over to read the collision rate of approach in knots and tenths.

Referring now to Fig. 11, this collision line is ascertained as soon as the wireless letter of another vessel is heard, and the parallel ruler (155) hinged at the lower end is swung over and clamped to the corresponding speed shown on scale (153).

As soon as the first submarine signal is received this parallel ruler is used to strike the collision line on the diagram, and the observer thereafter has only to note whether or not the actual distances measured follow or fall outside this line.

In case collision is to occur the bearing of the vessels does not change exactly as in the test prescribed by the "Rules of the Road," the rate of approach is uniform, and the successive distances measured would generate a straight line. If the bearing changes the successive distances generate a curved line.

It is now clear that by applying the "collision line" (106) in Fig. 11 to the distance first obtained it will show very soon whether or not the actual approach follows the collision line—in other words, whether the two vessels are changing their bearing.

A diagram will best illustrate this. Fig. 13, Plate 51, is a simple example of two vessels at *A* and *B*, each having an assumed speed of 15 knots on courses 90 degrees apart, each 5 miles from the point of crossing *C*. By preserving the speed and course collision would occur in the time necessary to run 5 miles, namely, 20 minutes.

In this case the solid lines show their successive positions, the bearings do not change, the triangles are similar, and the rate of approach is uniform.

If the speed of "B" is assumed as 21 knots she hauls ahead of "A," the bearings change as shown in the small dotted lines, and the rate of approach is non-uniform.

The same result occurs if "B" has a speed of 9 knots as shown in the broken lines, except that in this case "A" hauls ahead.

Referring now to Fig. 11, in the above cases the results would appear as shown in Fig. 14, Plate 51. The solid line *B* would be generated if collision occurred as in the first case.

In the second case the collision line would appear as B_1 and in the third case assumed as B_2. The dotted curves show the actual distances. If collision were to be possible the vessel would have to be at the points in Fig. 13 marked B_1 and B_2 respectively.

Other illustrative examples of the records in the receiver are shown in Figs. A and B, Plates 52 and 53, supplementing Figs. 13 and 14, Plate 51. In the latter cases vessels at *B* were assumed to have various speeds but keeping the same course (180°). In Figs. A and B vessels at *B* are assumed to be steering various

courses from 140° to 270° but with the same speed in each case, viz., 15 knots, and 5 miles apart when distance is first measured. "A" holds course east (90°); "B" is shown on courses 140°, 160°, 200°, 220° and 270°.

It should be noted that on course 270° the nearest approach is over 3½ miles, and only between 160° and 200° or 40° of the compass would the vessels approach within one mile of each other, or make any change in speed or course advisable.

As the vessels would constantly know their distance apart within a couple of ships' lengths, as well as whether the bearing was changing, it is apparent that collision is practically impossible.

It is possible to locate a vessel by the instrument shown in Fig. 12, after a sufficient run has been made, were this data necessary. The first distance measured gives the large circle shown as a locus, and the course and speed of the two vessels being known, a second circle is obtained. The intersection of this circle with the first circle moved with the observed vessel gives the location required. Practically the two graduated arms have the distances set on them and these points are brought together. A double solution results as shown. In practical navigation this should be unnecessary. In case the commercial type of submarine microphones is used, the side on which the observed vessel bears would be ascertained.

In the practical application of this method at sea, a standard wireless installation might be used, but such range and power are not required. A short wavelength of not more than 200 meters, such as is reserved for the use of amateur operators, would be sufficient for the purpose. An inexpensive set with a variable frequency would be practical by which the changing pitch and single letter would indicate an unmistakable fog signal. There would be no danger of interference with submarine signals. If more than one vessel were within the field of audibility, the variations in speed or course would eliminate any probability of confusion.

The recent simultaneous tests of the Berger and Fessenden submarine systems have shown an effective range of 10 miles for both. A range of 5 miles should show four times this intensity, and therefore this element in the system appears to be solved.

The method above outlined appears therefore to furnish the information necessary for safe fog navigation, namely, at a range of over 5 miles, speed and course of other vessel, whether her bearing is changing, sea room to maneuver if necessary, the condition that both vessels are able to hold their course and speed until bearing change is ascertained, and in addition the distance separating the vessels. Vessels having this knowledge will in nine cases out of ten find themselves passing more than one mile apart without either changing her course or speed.

The apparatus has been planned to operate with the greatest possible simplicity.

The sending apparatus (Fig. 10) is set for the course and speed and is thereafter automatic, operating until shut down after the fog lifts.

As soon as a distinctive wireless fog letter of a vessel is heard the pivoted scale in Fig. 12 is swung to the letter, the speed set as soon as the letter is again

received from her, and the interval of time noted. Her rate of approach to cause collision is read on the scale arm and transferred to the receiving instrument (Fig. 11). As soon as the submarine wireless letter is heard, the receiver, Fig. 11, is started. Operating the Morse key measures the successive distances. The rate of approach is thus observed and compared with the "collision line."

Investigation will demonstrate that with an effective radius of 5 miles nearly a quarter of an hour will usually elapse before maneuvering may be necessary, and in the great majority of cases any change of course and speed will not be required.

DISCUSSION.

THE CHAIRMAN:—Both of these papers, the one by Mr. Millet and the other by Commander Sawyer, are open for discussion.

MR. HARVEY D. GOULDER, *Member of Council:*—I just want to say a few words in recognition of the value of these two papers. There is a gentleman here, Mr. Frank Smith, who can tell you about our experiments with submarine signaling on the Great Lakes, and all of these things tend to a betterment of the service. We have on the Great Lakes what we call the Great Lakes Protective Association, a self-insuring or co-insuring institution. The formation of this association was brought about because of the things referred to in these papers. We have established lanes on Lake Superior and Lake Huron which we have established without any authority of law, but by moral force. We also have lanes in the connecting rivers, where we are usually very much congested in our traffic. When this association was formed the insurance rate was 6 per cent—had been 6 per cent, and was to be 7 per cent. This year, 1914, we made an initial contribution of 3.5 per cent to the actual cost of the insurance, and it brought down the cost of insurance to about 2 per cent. That has resulted from the introduction of improvements which are touched upon in these papers. We had to take in the human equation. It is hard for us to put off old shoes that are easy; what I mean is, it is hard for us to discard our ordinary habits of business, and we have found difficulty, much difficulty, with our masters, in getting them to adopt these modern appliances. On Lake Huron we give the shore line, the west line, to the upgoing steamers, because there they get the lights and the fog signals at various places, and the man who is going down says, "I ought to have the same thing." So we have to take that human equation into consideration; it goes back to the proposition of Capt. George Judson, who never had a collision, and who was once much talked about because you never could get him into a collision—he would keep a half-mile away from everything else. That was a criticism. The answer was that George Judson was a successful master and never had a collision.

Let me say further that we have our duplicate channels; we have only one bad place on the Lakes that we need to remedy, and that is the Southeast Bend in St. Claire River where, when coming north, the steamers have to steer southeast part of the distance. There is an opportunity to have a channel on the other side. We are getting these different channels and

getting away from these accidents. If I may use the phrase, we are standardizing our accidents, we are standardizing our costs with a result that they have dropped from 7 per cent down to less than 2 per cent. I wish Mr. Frank Smith would speak on this subject. I know his company has been experimenting with the submarine signals.

Mr. F. B. Smith, *Member:*—I have to say, so far as the Pittsburgh Steamship Company is concerned, that it is the largest shipowning company on the Lakes, and in fact the largest under the American flag outside of the U. S. Navy. We have had these submarine signals installed on all our ships, and, as Mr. Goulder says, it was a pretty hard proposition to get the men to take to the system kindly. The men who were to receive the greatest benefits from the system were the hardest to get to adopt them. When the submarine signals were first put in, some of our best navigators said they were able to sail their own ships without any help from any patented device, and they did not approve of them, but since they have been given time to use these things and think them over, these very same men are the strongest advocates of the submarine signal system that we have. The men have the right spirit in them, but they do not understand the theory of aids of that kind.

We have frequently had reports where they have heard these submarine signaling bells anywhere from 15 to 30 miles, and we have had reports of the bells being heard for a distance considerably more than that. Of course, the benefits derived from the system depend very much on the sensitiveness of the hearing apparatus of the master. Some can distinguish down to one-quarter of a point, very easily, the direction of the bell, while others have a greater variation, as they do not hear the bell as plainly—are not as sensitive in their hearing. But with ordinary hearing, they have no trouble whatever in locating the direction of the bells. It is certainly a great benefit and has undoubtedly saved a great many groundings; and with this apparatus spoken of now, if it works successfully, that is the system of intercommunication between the ships, it ought certainly to be a great thing in the prevention of collisions.

As Mr. Goulder has said, we have a system on the Lakes of routes, the same as is proposed on the ocean by some of the lines, our up-bound ships taking the line nearest the shore and the down-bound ship farther out into the lake. If that rule were followed to the letter it would undoubtedly prevent a good many collisions which now occur, but just as with the submarine bell at first, the captain wants to sail his own ship and take his own course. But they are coming to it, for last winter the feeling in favor of it was so strong that by a vote of the captains in the employ of the Pittsburgh Steamship Company it was made a permanent order that the captains should follow the different courses laid out. We cannot control all the other ships running on the Lakes, but we are controlling the matter as far as our own line is concerned, and doing it on the recommendation of the men who are actively in the service—on the recommendation of the captains of the ships. We are very much interested in the submarine signaling, and the further it is carried forward, and the more perfect it becomes, the better we will be satisfied.

The Chairman:—Mr. Goulder's reference to Captain Judson reminds me of Commodore Van Santvoord who always owned the fastest boats on the Hudson River, and the line founded by him still owns them—his orders were "always go astern of the other fellow, and you will not get hit."

If there is no further discussion, we will ask Mr. Millet to close the discussion on his paper, and he will be followed by Commander Sawyer with his closing remarks.

MR. MILLET:—I have very been much interested in what the speakers have had to say. I want to say, gentlemen, in the beginning, that I am not a navigator or a scientist, but it was my job—having spent several years in assisting to perfect this system—to go abroad and convert the shipping companies and lighthouse authorities to the belief that they must abandon the air and use the water. I think if I had gone to either of the gentlemen who have just spoken and told them that was what I wanted them to do, they probably would not have received me with open arms, and, in fact, nobody did. One reason why your captains did not take any more interest in the matter was that it is not taught as an aid to navigation, and it should be. It should be taught at Annapolis and should be in all your text-books; it should be just as much a matter of necessity for the captain, pilot or mate to know how to use this apparatus as any other. If the commanding officers were given an opportunity to practise on their own ships when there is no danger, so that they may know the sounds of their own vessels, we would get ahead twice as fast as we have done. It would be the easiest thing for Nature to put our ears on our shoulder-blades if she wanted to, but if she had done that we would have heard our heart beat. One reason why the tanks are put so far forward is so that they cannot hear all the movements of the machinery. In a general way the tanks are placed there (indicating on blackboard). Let us suppose we have oscillators instead of carbon microphones. In the first place, the microphone, as you know from your telephone experience, hears everything that comes to it—scratch the holder with your finger, and you get that sound. Ships' noises jar the microphone in just that way, and they contribute to sending into your ears sounds you do not want to hear. I am not in the least interested financially in any system. I am simply anxious to contribute anything that comes from my experience extending over several years, anxious to contribute any knowledge I may possibly have on this subject to the common experience.

The only difficulty I have ever had in conducting tests for the British, French or German navies was ships' noises at extreme distances—or people would talk in the room in which the instrument was located, or hammer on the walls, or the pumps would start when they ought not to, and these interfered with the proper hearing. I often wished there had been some way of cutting out ships' noises, the rumbling of the screw, the vibration of the engines, or what-not. The new invention called the oscillator does that. It is not only a good transmitter of sound, but it is a better receiver of sound than the carbon transmitter is. Consequently, you are not at all disturbed by anything which occurs on board the ship.

Let us look into this thing further. You have two tanks like that (indicating on blackboard) and get the direction all right. Suppose you put two more back here (indicating). We know there is a certain zone of silence back here. With reference to these two tanks, that is the zone of silence, because the sound cannot go from this side of the ship to that tank. You will have another zone of silence there (indicating on blackboard). If you swing your ship for the benefit of the signaling apparatus, the same as you do for your compass, you will know where the zones of silence are; and if you know those zones of silence with reference to any bells that may be anywhere, that is all you want to know. If the bell is over the stern, that is a good place to keep it. As I have said, I have no desire to advance any particular system. I have no commercial interest in any, but what I want to do is to show that these systems are practicable and efficient. It seems to me if this ship can send through

her oscillator to the other ship her speed and her course, and they can interchange that information instantly by the Morse system, that is about all they want to know; that is to say, it would be at least a very great factor in saving these ships from collision, for the reason which I advanced in my first talk, namely, that this does not require any technical knowledge, but simply requires a man who is a good observer. He should not be in charge of the ship if he were not, because, after all, the use of this apparatus is only intended as a means of intensifying his ability as a navigator and enabling him to concentrate his attention on the bridge.

MR. GOULDER:—In connection with the definiteness of these sound signals, Judge Addison Brown, the former District Judge in New York, who was a leader, if not without a peer in admiralty judgment, in the case of the S. S. Lepanto, 21 Fed. Rep., after reviewing the whole subject, taking in "Tyndall on Sound" and all that was known, held that a mistake of five points in the supposed direction of a whistle sound could not be called a fault. He made the range of five points.

COMMANDER SAWYER:—I have been asked to explain more particularly how the distance between ships in a fog is obtained.

By reference to Fig. 11, Plate 50, this distance is read off directly upon the scaled paper from the length of the lines, the paper being marked for each mile and one-tenth of a mile. All the operator on watch has to do is to press his key when a wireless letter is received, and release the key when the corresponding under-water signal is heard. The wireless letter travels 180,000 miles in a second and the under-water signal three-fourths of a mile in the same time. In the U. S. S. Arkansas-Utah tests the time between the wireless signal and the submarine signal would have been 13 seconds or nearly a quarter of a minute at the longest ranges reached—about the time you would ordinarily count thirty. An average telegrapher or signalman uses one-tenth second for a dot, and an unskilled observer ought to be able to work in twice that time which would measure the distance between the ships to 300 yards, or one to two ships' lengths. This is much closer than necessary for navigation purposes so far as fog is concerned.

In regard to the question of direction, which Mr. Millet suggests may be obtained by the use of submarine signals alone, it does not seem possible that this will ever be satisfactory by itself for fog navigation.

Suppose that a submarine signal is heard on one side only. The bearing is unknown, but only the fact that the other vessel bears somewhere between 16 points of the compass. If the attempt is made to locate the bearing as in the case of a submarine bell, the two vessels would have to change course and endeavor to head for each other. As both vessels are moving and turning, it would be much more difficult, if not impossible, to determine the approximate bearing. The distance between the vessels would be unknown, and it would seem that an effort to utilize this method would increase the danger of collision as compared with vessels not so equipped.

It must be remembered that vessels may collide on every bearing but cannot collide at every distance.

A practical seaman is never afraid of collision if his vessel never gets within a mile of another, and with that assurance, all he requires is, first, to know whether the vessels are

changing their bearing; and second, not to have to change his speed and course in a fog unless absolutely necessary.

My proposed method fulfils all these conditions.

Most of the collisions in a fog occur after vessels sight each other and while both are maneuvering to avoid collision, and the method proposed by Mr. Millet for obtaining direction by submarine signals would tend to produce exactly this situation. Even if we assume that you determined the bearing of the other vessel exactly, so long as you had no knowledge of her distance there might still be danger of collision.

If we compare the submarine system alone with the wireless system alone for obtaining bearings in a fog, the wireless appears clearly superior, as the radio-goniometer does not require any change of course to ascertain the bearing. Both depend for accuracy upon the relative degree of intensity of the sounds, and are therefore affected by errors both of the observer and of the instrument.

As the intensity curve of sound is sinuous, the lack of definite fix hardly supplies the wants of the practical navigator, while a reasonably accurate knowledge of the distance would exactly meet his needs.

The submarine signal will owe its unique value in fog navigation to the fact that in combination with wireless it will make possible accurate knowledge of the distance separating vessels, and make it possible to know whether the bearing is changing, with ample distance remaining to change course if necessary.

No other methods will accomplish this result.

THE CHAIRMAN:—I am advised that just before the close of the morning session there is to be an interesting moving-picture film to be shown in connection with Mr. Tawresey's paper, which was read yesterday, on the launching of the Oklahoma.

We will now have paper No. 12, "The Behavior of Riveted Joints under Stresses," by Mr. James E. Howard.

Mr. Howard's paper was presented.

THE BEHAVIOR OF RIVETED JOINTS UNDER STRESSES.

By James E. Howard, Esq., Visitor.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

The efficiencies of riveted joints under rupturing tensile stresses constitute the values on which working loads are commonly based. Alleged factors of safety are employed, fortunately not less than five on important work. One of the reasons why it is fortunate that a large factor of safety is used is found in the fact that a fairly good distribution of the loads is not always characteristic of riveted construction. Furthermore, the unit values on which computations of the strength of riveted joints are based, in some respects, are not fixed values as they are generally taken to be.

The most important feature of the case, however, resides in the elastic behavior of the joints, one which appears to be ignored, in consequence of which local strains are introduced entirely at variance with those which purport to be present in well-designed engineering structures. Nominally the elastic limit of the material represents a limit which should be approached with temerity. As a matter of fact few, if any, riveted structures are erected which are free locally from strains which do not exceed the elastic limit of the material. The structures are not necessarily endangered by the presence of such overstrains. It will depend upon the character of the work which they have to perform, however, whether or not ultimate failure will result and the place of rupture be located by an overstrained zone.

It may be remarked, with assurance, that after a limited number of repetitions of stresses, twofold or threefold, the working loads are adequate to effect rupture, for working loads which are based upon the usual so-called factor of safety of five. The behavior of riveted joints under stresses leads to this inference. Multiple riveted, double butt-strap joints may have a degree of rigidity equal to or even in excess of the solid plate for comparatively low tensile or compressive stresses, but loads ranging from, say, 15,000 to 25,000 pounds per square inch commonly show a material divergence in the behavior of a joint over that of the solid plate.

When frictional resistance contributes toward the initial rigidity of the joint, as it commonly does, it is uncertain whether the favorable showing of the joint in the laboratory test is realized and maintained under service conditions. Vibratory effects and changes in temperature seem likely to cause a creeping of the plates and disturb the initial state of the different ply, when taken in conjunction with a constant load, or more marked, it may be, in the case of alternate stresses. In riveted joints, as in many other engineering examples, a careful analysis of the case is not reas-

suring that permanency is being fully provided for. Not that iron and steel are not enduring, but safety lies in the adoption of what appears to be low working unit stresses, in order to avoid excessive local strains not contemplated in the design of the structure.

Referring specifically to the strength of those parts on which reliance is placed in the design of a riveted joint, first comes the tensile strength of the plate, taken as a whole. Next to this the strength of the steel between the rivet holes, that is, on the net section. On the latter section the strength per unit of area is not the same with different pitches. It may be greater or less than that accredited to the gross section, per square inch. It is also modified according to whether the holes are drilled or punched, and may be greater in one case or the other according to the pitch of the rivets or, rather, the distance from rivet holes to rivet holes. It is not likely that the strength with punched holes will be greater than with drilled holes in practice, since very close pitched work is required to bring about such a result, much closer than other considerations in a good joint render permissible. The reason, however, that a punched plate may display greater strength than a drilled one is found in the hardening of the steel by the punch and die at the sides of the holes.

The tensile strength on the net section of the plate is usually greater than on a strip of uniform width, several inches in length. The increased area of metal on each side of the center line passing through the rivet holes has a reinforcing effect on the net section of the plate. This gain in strength is a substantial one in single-riveted work, and in multiple riveting when the same pitch is maintained in the different rows.

The reinforcement, as natural to suppose, is greater in close-pitched than in wide-pitched riveting. The reinforcement is at the sides of the holes, but if they are very far apart there results a loss instead of a gain. The reinforcement is therefore not a fixed amount, but depends upon the proportions of the joint. It follows that the strength of a single-riveted joint, whether butt or lap, will not, with changes of pitch, remain proportional to the ratio of net to gross section of plate. As the net section increases relative to the gross section there is a loss in the reinforcement in strength per inch of area on the net section. Instances have been met in which one of these features practically compensated for the other and resulted in furnishing joints of several pitches, each of substantially the same efficiency in terms of the tensile strength of the solid plate.

When the pitch of the riveting has been considerably increased, as witnessed in butt joints with double covers, in which one strap is considerably wider than the other, joints which fail by the rupture of the plate not infrequently show a diminution in strength on the net section. The plate tears apart at the outside row of rivet holes, in detail. The presence of a few rivets, wide spaced, in the outside row promotes tearing of the plate, the line of rupture starting at a rivet hole and reaching an advanced stage before the plate at the middle of the pitch is separated.

It will be understood from this that tables of proportions of riveted joints

based upon fixed values for the strength of the net section of plate are not in harmony with the results of tests on which the preceding remarks are based. Furthermore, it seems probable that modifications in strength would be peculiar to each grade of steel, and mild steel plates which display a considerable portion of their ductility just before reaching their tensile strength would show a difference in behavior over those of less ultimate ductility or plates of quite different stress-strain diagrams. The strength of riveted joints hardly admits of being reached by computation in which only a balancing of areas is taken into consideration, assuming fixed values for the component parts.

Other details might be referred to such as the compression on the bearing surface of the rivets, as modified by diameter of rivet or change in pitch, also by the relief afforded the outside row of rivets in multiple riveting. Still further, the relative advantages of chain and staggered riveting could be taken up, also the question of distance between the different rows of rivets and the number of rows which are desirable to use. The thickness of the cover plates in single and double butt-strap joints should be considered, and in splice plates whether it is desirable or not to vary the distances between rows of rivets. This enumeration of details necessary to consider in a comprehensive review of the subject might be extended to very great length.

Tests on staggered riveting have led to the observation that it frequently happens that the tendency of the plate to draw down along shearing planes, oblique to the direction of pull, encounters in its course a rivet in the adjacent row. That is, the design of the joint was such that rivets in adjacent rows occupied critical positions with reference to each other, and while the zigzag path from one row to the other was longer than from rivet to rivet of the same row, nevertheless the plate showed a preference to fracture along this greater length, and the interposition of rivets in the second row in critical places was a probable source of weakness.

Chain-riveted work creates a favorable impression when observing and comparing the behavior of different types of joints under test. The distance between rows in chain riveting admits of being very much reduced over current practice without impairing the ultimate strength of the joint.

It will be of interest to refer to the strength of riveted joints at higher temperatures. Under exceptional circumstances the joints of steam boilers might be exposed to temperatures considerable above that due to the steam pressure. Joints have been tested up to a temperature of 700° F. The strength of the joints followed the law which governs the strength of plain bars of steel, at different temperatures. There was a drop in strength at 200°, followed by an increase, which reached a maximum at about 500°, after which the strength fell off. Among the several joints tested at 500° the maximum gain over the cold joints was 27.6 per cent. The tensile strength on the net section reached 81,050 pounds per square inch, against a strength of 58,000 pounds per square inch, on the cold tensile test strip, an increase of nearly 40 per cent. The shearing strength of the rivets showed an increase at the higher temperatures of these tests. Furthermore, it was found that joints which

were overstrained at these higher temperatures, even beyond the limits of duplicate cold tests, when subsequently tested to destruction at atmospheric temperatures, retained substantially the strength which they had when hot. There was some loss in the ductility of the steel, but without approaching a state of brittleness.

So much for the ultimate strength of riveted joints. Under some circumstances it is probable that the riveted joints in an engineering structure might for a time resist loads approximating those which were required to effect rupture in the testing machine. More commonly they probably would not, nor would they be expected to display the ductilty witnessed in the laboratory behavior of the joints. Stated in other words, structures designed to have a factor of safety of five based on the ultimate strength of these joints would not as a matter of fact in service possess such a margin in strength and safety. Attention must be given the behavior of the joints under stress, and whether the working loads are constant or variable, direct or reversed stresses; and, in the case of repeated stresses, how many repetitions there will be and the maximum stresses involved.

The examination of some stress-strain curves prepared from earlier tests show that the joints in general take a very wide departure from the curve representing the solid plate, this being noticeable at 15,000 pounds per square inch, and in some joints as early as 10,000 pounds. This was true with joints having efficiencies of 70 to 80 per cent of the solid plate. Among the joints thus compared were double- and triple-riveted butt joints, and quintuple joints in which the inner butt strap was wider than the outer one.

Under 15,000 pounds per square inch, the joints in general, among the strong ones, displayed an extension one and a half times to over twice the extension of the solid plate. These joints were of the type which are used in steam boiler construction. Observations on the behavior of double-riveted lap joints on some steam boilers which had been in service showed greater extension across the longitudinal seams at the middle of the width of the sheets than in the vicinity of the girth seams, referring, in the tests just mentioned, to the effect of hydrostatic pressures applied just above the pressures at which the boilers had been worked.

It is a feature of interest whether riveted seams retain their primitive state under prolonged service stresses, or whether they do not slip and eventually display increased extensions under lower loads than suggested by the laboratory tests.

Cover plates and splice plates in bridge work do not immediately take up the full stresses which are acquired along the length of the plates after several rows of rivets have been passed. The loads are progressively taken up by these splicing members.

From the limited number of observations which have been made it cannot be said that the rigidity of joints on actual structures is greater than would be expected, judging from the laboratory tests. If there is a difference, they are probably less rigid in actual structures.

The frictional resistance due to the shrinkage of the rivets is apparently a factor in the early behavior of a joint. The shrinkage force which is available is, or

should be, represented by the elastic limit of the rivet metal. Whether this force drawing the plates together is acting to its full extent will depend upon the manner in which the riveting is done. A limited range in temperature in cooling is sufficient to apply a contractile force equal to the elastic limit of the rivet metal. But since the hot rivet metal has a very low elastic limit it is necessary to hold the plates together firmly until the rivet has cooled to nearly its final temperature. This requirement is an obstacle to rapid driving, as will be readily seen, but full efficiency in frictional resistance between the plates requires its observance.

To attain a high degree of efficiency a state of rigidity in the joint, comparable to that of the plate, is essential. If not attained, the distribution of the stresses will not be as they are expected and computed. The few examples in which the strains in structures have been measured do not furnish ground for the belief that very good distribution is attained in current practice in all classes of structures. The conditions attending marine work would seem to make greater demands on the riveting than in most engineering structures.

This paper has not taken the form which it was hoped that it might. It was desired to present orderly arranged data covering the details which have been mentioned and others which have not been touched upon. This was found to be impracticable in the time which could be given to it. It is believed, however, that this review of the subject will show its general status and indicate those features which should be considered when designing riveted connections, and, furthermore, that riveted joints are not to be taken as the equivalent of the solid plate, except, it may be, for working loads of small magnitude.

THE CHAIRMAN:—Gentlemen, this paper is before you for discussion. Does any member wish to discuss it? If not, in your behalf, I tender the thanks of the Society for his interesting presentation of this matter.

We will now proceed to the next paper, No. 11, "Our First Frigates. Some Unpublished Facts about their Construction," by Hon. Franklin D. Roosevelt. In the absence of Mr. Roosevelt the paper will be presented by Mr. Linnard.

Mr. Linnard read the paper.

OUR FIRST FRIGATES. SOME UNPUBLISHED FACTS ABOUT THEIR CONSTRUCTION.

By Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

After the sale of the frigate Alliance in 1785 the United States ceased to have a navy. It is, of course, well known that the present navy of the United States had its origin in the Act of Congress of 1794 which authorized the building of six frigates. Of the causes which led to the foundation of the navy and the actual work of constructing our first ships little, however, is known.

The navy of the United States first came into being, not as a measure of defense, but as a means of affording protection to commerce. Almost immediately after the close of the Revolutionary War American merchant vessels began to suffer from the depredations of corsairs belonging to the Barbary powers. In 1785 the schooner Maria of Boston and the ship Dauphin of Philadelphia were captured by the Algerines and their crews held for ransom. Many attempts were made by the administration to come to some agreement through diplomatic channels with Algiers and Morocco, but the negotiations dragged on and American shipping to Spain and the Mediterranean continued to be threatened by the corsairs. That the officials of our government were seriously concerned and proceeded to consider plans to give armed protection to our shipping, is shown by an old letter-book now in the possession of the library of the Navy Department at Washington. The Navy Department did not, of course, come into existence until 1798, and this book contains the out-letters of the War Department which concern navy affairs from 1790 until the business was turned over to the Navy Department in 1798.

The first entry, dated October 30, 1790—nearly four years before the first ships were authorized—is a copy of a letter from Capt. John Foster Williams, formerly of the Massachusetts Navy in the Revolution, to the Secretary of War, sending him, agreeably to his request, an estimate of a frigate of 900 tons, thus proving that at this early date the administration of President Washington was gathering data regarding the building of ships of war. This is followed by estimates of cost of a 40-gun frigate, of ordnance stores, of the pay of officers and crew, of provisions, of sails and rigging, and of the annual expense of maintenance. The letter-book shows that in 1791 these and other estimates were submitted to a committee of the Senate.

No action seems to have been taken, however, and the depredations of the Barbary States continued until in 1793 over a dozen American ships had been captured. Late in that year Samuel Hodgdon, of Philadelphia, submitted an estimate of the

cost of a frigate of from eight hundred to twelve hundred tons. His figures show £23 16s. 9d. per ton.

On January 2, 1794, the House of Representatives passed a resolution—

"That a naval force adequate to the protection of the commerce of the United States, against the Algerine corsairs, ought to be provided."

A committee, of which Mr. Thomas Fitzsimons was chairman, was appointed to report. The Secretary of War sent to this committee on January 4 the estimates made in 1790 for building and equipping frigates, and also the estimate made by Samuel Hodgdon. Two weeks later the committee reported that in view of the size of the naval force of the Algerines they would recommend that four ships of 44 guns each and two ships of 24 guns each would be sufficient to protect the commerce of the United States; that the cost of this force would amount to $600,000, and that the annual expense of maintenance would be $247,960. The committee further proposed the levying of certain additional duties to pay for this armament. Closely following this the first bill to create a navy passed Congress and was approved on March 27. Its preamble recognizes the considerations which induced its passage in the following words: "Whereas, the depredations committed by the Algerine corsairs on the commerce of the United States, render it necessary that a naval force should be provided for its protection—Be it, therefore, enacted," etc. The law provided by purchase or building for four ships to carry forty-four guns and two ships to carry thirty-six guns each. The appropriation made available was $688,888.82, but it was provided "that if a peace shall take place between the United States and the Regency of Algiers no further proceeding shall be had under the Act."

The War Department made immediate preparations. The letter-book shows that Joshua Humphreys, of Philadelphia, at that time the seat of the National Government, was verbally asked to make calculations of materials and prices. On April 1, 1794, John Hackett, of Salisbury, Mass., the builder of the Alliance of the Revolution, was asked to come to Philadelphia for the purpose of giving his advice. On April 21 the Secretary of the Treasury was notified that the President had decided that the 44-gun frigates should be built one each in Boston, New York, Philadelphia and Portsmouth, Virginia, and the 36-gun frigates one each in Baltimore and Charleston, S. C. The molds for the timbers were "preparing and nearly finished." It appears to have been the duty of the Secretary of the Treasury to take charge of the purchase of materials, and Joshua Humphreys' estimate, giving a complete list of the varieties and sizes of timber and plank for a frigate of 147-foot keel, 43-foot beam, 14-foot hold, 6 feet 9 inches between decks and 7-foot waist was sent to the Treasury Department. It was suggested that the live oak and red cedar be obtained from the islands of Georgia and that the vessels be constructed under the direction of agents. No decision had been reached on building by contract, though General Knox, the Secretary of War, says: "I should find great satisfaction in a contract if one upon solid price could be obtained." Several other estimates were made

and the letter-book contains an interesting list of dimensions of over sixty French and English vessels, both warships and Indiamen. Mr. Humphreys constructed a model of a proposed frigate of 147-foot keel and 42-foot beam and General Knox appears to have asked the opinions of several gentlemen on the sailing and fighting qualities of such a ship.

On June 21 Joshua Humphreys was directed to erect a temporary building for the making of molds. On June 25 it was determined that John Morgan should be the principal constructor at Norfolk and Joshua Humphreys at Philadelphia. Henry Jackson was appointed naval agent at Boston, John Blagge at New York, and Jeremiah Yellot at Baltimore. Mr. Humphreys' compensation was placed at $2,000 per annum, to date from the previous first of May "in consideration of his incessant application to the public interest in adjusting the principles of the ship, drawing up draughts and making models, etc."

It was decided that the principal part of the material—timber, iron, cordage and sail cloth would be procured in pursuance of a special arrangement through the Secretary of the Treasury. The labor and all other materials would be procured by the naval agent, who would receive a commission of 2½ per cent. The constructor would be responsible for all technical details and the execution of the work would be under a captain acting as superintendent. In addition to the previous appointments the following naval agents were chosen: William Pennock, at Norfolk; Gurney and Smith, at Philadelphia, and John Langdon, for whom Jacob Sheaffe was later substituted, at Portsmouth, N. H. From the latter location it is made clear that it had been decided to build one of the 36-gun frigates at Portsmouth, N. H., instead of at Charleston, S. C., as previously suggested. Also, the six captains who had been appointed by the President were assigned as superintendents of construction as follows: John Barry, for the ship building at Philadelphia; Samuel Nicholson, at Boston; Silas Talbot, at New York; Richard Dale, at Norfolk; Thomas Truxton, at Baltimore, and James Seaver, at Portsmouth, N. H. Early in August Mr. David Stodder was appointed naval constructor at Baltimore. Mr. John Morgan, who had been appointed naval constructor at Norfolk, was sent south to superintend the cutting and preparation of the timber in Georgia. The choice of George Claghorne to be naval constructor at New York, of James Hackett at Portsmouth, N. H., and of Foreman Cheeseman at Norfolk, and the appointment of Isaiah Cox as naval agent at Philadelphia, completed the personnel of the new work.

Meanwhile the detailed drawings and measurements were being rapidly pushed by Joshua Humphreys, while Capt. Thomas Truxton was working on the spar and sail plans. The drawings were completed by Joshua Humphreys before October 1 and immediately questions arose as to the choice of certain materials. Humphreys appears to have advocated the use of pine beams instead of oak. In this he was supported by Captain Barry, and the Secretary of War after some hesitation decided on pitch pine beams for the 44-gun frigate to be built in Philadelphia. Captain Barry, however, journeyed to Georgia to inspect the standing live oak and as a result of this visit it was decided that oak should be used for the flooring and rising tim-

bers of the frigates. In order to prevent all errors the molds prepared by Mr. Humphreys were shipped to Georgia and it was directed that the timber be cut in January and February, these months being recommended as the most suitable of the year for cutting timber.

In this connection it may be of interest to give extracts of the principal dimensions of the frigates, as contained in Humphreys' final reports:—

"44-GUN FRIGATES.

"Length of gun deck from rabbet of stem to post 174 feet 10½ inches.
Length of keel 145 feet.
Molded breadth of beam in the extreme part 43 feet 6 inches.
Height of wing transom above rabbit of the keel 25 feet 8½ inches.
Height of lower deck transom above rabbit of keel 20 feet 9 inches.
Height between gun deck and lower deck 6 feet 4 inches.

"36-GUN FRIGATES.

"Length of gun deck from rabbet of stem to post 163 feet 7 inches.
Length of keel 136 feet.
Molded breadth of beam in extreme part 40 feet.
Height of wing transom above rabbit of keel 24 feet.
Height of lower deck transom above rabbit of keel 19 feet 2 inches.
Height between gun deck and lower deck 6 feet."

In both types of ship the keel to be of good sound white oak in three pieces, the middle piece to be not less than 80 feet.

In December the Secretary of War, at the request of the House of Representatives, submitted a report showing the progress made up to that time. He calls attention to the difficulties of construction in the following terms:—

"That few or no materials of any sort either for construction or equipment existed in their proper shape; that everything if not to be created was to be modified; that the wood of which the frames were to be made were standing in the forests; the iron for the cannon lies in its natural bed, and the flax and hemp perhaps in their seed; that the materials will soon be collected and the building vigorously pushed, so that the frigates according to the opinions contained in the documents herewith submitted may be afloat in the course of the year 1795."

In view of the later history of our first frigates, and especially of the records of the Constellation, Constitution and United States, the following quotation from the report of Joshua Humphreys is of interest:—

"As soon as Congress had agreed to build frigates, it was contemplated to make them the most powerful, and at the same time the most useful ships. After

the most extensive researches and mature deliberations their dimensions were fixed and I was directed to prepare the draughts; which was accordingly done and approved. Those plans appear to be similar with those adopted by France in their great experience in naval architecture; they having cut down several of their 74's to make heavy frigates, making them nearly of the dimensions of those for the United States. From the construction of those ships it is expected the commanders of them will have it in their power to engage or not any ship as they may think proper; and no ship under 64 now afloat but what must submit to them. These reasons are paramount to all objections, and annihilated opposition."

The report of Tench Coxe, Commissioner of the Revenue, states that work had already begun in cutting the timber in Georgia; also, that a contract had been executed with Messrs. Levi Hollingsworth, Son & Company, of Jersey and Pennsylvania, for 92 tons of cannon ball and 340 tons of kentledge. Another contract with Messrs. J. J. Faesch & Company, of New Jersey, for 98 tons of cannon ball and 256 tons of kentledge. Another contract with the Cecil Iron Company, of Maryland, for half of the 24-pound cannons. Another contract with Messrs. Brown, Francis and Company, of Providence, for one-third of the 24-pound cannons, and a contract with the Boston Company for sail cloth for all the frigates.

In January, 1795, General Knox was succeeded by Timothy Pickering as Secretary of War, but the organization for building the frigates does not appear to have been changed in any way. In February, 1795, a quantity of copper arrived for the ships from Europe. As the work progressed numerous questions regarding materials arose, but it appears that every effort was used to build the ships in the most durable way possible. Some of the constructors desired to use inferior materials for the deadwood, but it was ascertained that live oak could be obtained and its use was insisted on. Captain Dale, who was supervising the construction of the frigate at Norfolk, applied for, and was granted, a furlough for the purpose of making a voyage to China, and his work was put in the hands of Capt. Samuel Barron. In the absence of John Morgan in Georgia, Josiah Fox, Humphreys' assistant in draughting the original plans, was appointed as acting constructor at Norfolk. In July, 1795, Messrs. Gurney and Smith resigned their agency for the frigate building at Philadelphia and Mr. Tench Francis was appointed naval agent.

By this time, about a year after the preliminary work had been commenced, it became apparent that the difficulties of getting the live oak in George were greater than had been foreseen. Full and regular supplies for only two frigates could be kept up. To maintain the working organization on all six ships with adequate supplies would have proved unnecessarily wasteful and it was therefore decided on June 29 to suspend the work on the four ships building at Portsmouth, N. H., Boston, New York and Norfolk, continuing the building, with all supplies available, at Philadelphia and Baltimore. The Secretary of War says:—

"Besides the saving of expense by changing the plan as now proposed, other advantages may arise. Two frigates may be completed many months before the whole if carried on together could be finished; and should there be a call for their service they might be equipped and sent to sea while the rest were progressing. Some errors may be committed in the construction of the first frigates or improvements suggested. Then in the residue the errors may be avoided and the improvements adopted."

Timothy Pickering's report to Congress shows the progress of the work up to December 12, 1795. He states that all the live oak timber will be cut and transported to the different ships at farthest by the next mid-summer. The keel of the frigate at Philadelphia had been completed and laid on the blocks, the pieces bolted to each other; the stern frame completed and ready for raising; two-thirds of the live oak for the frame received; many of the frames put together and bolted, two-thirds of the planking received; the deck beams, live-oak knees, masts, bowsprit, yards and their spars procured; the copper sheathing received, and much of the equipment, including even the bunting for the colors, was already in the public stores.

The 44-gun frigate at New York had her keel completed and laid on the blocks, the pieces bolted to each other, and about a quarter of the live oak timbers for the frame had arrived. The stern frame was not yet complete and several transoms were wanting; the planks for the outside of the ship were nearly all cut and a great part had been put in the sea water to draw out the sap and to season them; the spars had been received and were ready for finishing and all the necessary contracts entered into and articles daily arriving. Unfortunately a large schooner with live oak bound to New York was lost on Cape Hatteras with many of the principal pieces of timber necessary for the frame.

The keel of the 44-gun frigate building at Boston was completed and laid on the blocks, the stern frame almost ready to raise; about two-thirds of the live oak timbers received and a great part bolted together in frames and ready to put into the ship; the planking had been received and was seasoning; the copper was in the public stores, and the spars were ready for working and all contracts in a forward state.

About the same state of completion appears in the case of the 44-gun frigate building at Norfolk.

The 36-gun frigate at Baltimore had her keel laid on the blocks and bolted together. Two-thirds of the oak timber had arrived; part of it had been bolted together in frames; much of the plank and all of the copper had been received; the spars were ready for delivery, the boats building, and the articles contracted for daily arriving.

The condition of the 36-gun frigate building at Portsmouth, N. H., appears in about the same state of forwardness.

Meanwhile, the Department of State had continued its negotiations with the Dey of Algiers. A treaty was entered into on September 5, 1795, by which the Dey

agreed not to molest American shipping in consideration of an annual payment to him by the United States and other conditions. This treaty was duly forwarded to the United States and the President at once called the attention of Congress to the fact that, in accordance with the existing law, no further progress could be made in building the frigates, peace with Algiers having been concluded.

In response to inquiries Congress was informed that it was estimated that $453,272 would be necessary to complete the frigates in addition to the original appropriation of $688,888.82. The letter-book also contains under date of January 20, 1796, a statement of the quantity of materials most essential for building the frigates for the service of the United States, the quantity of each article actually delivered into the navy yards and what was deficient, and an account of the moneys already expended. Congress, on April 20, passed an Act authorizing the President to continue the construction and equipment of two of the frigates of 44 guns and one of the frigates of 36 guns, and appropriating for this purpose the unexpended balance of the original appropriation intended for the six frigates, and also the sum of $80,000 which had been appropriated on June 9, 1794, for the provisional equipment of galleys, but no part of which had been expended. This action discontinued the work on the other three frigates, and it will be seen that at this early date Congress failed to recognize the needs of the country, and by a half-and-half policy incurred in the end greater expense and less efficiency. The Secretary of War immediately issued orders stopping all operations on the ships building at New York, Portsmouth, N. H., and Norfolk, and steps were taken to sell the perishable material at these places. Such materials as could be used in the frigates whose construction was to be continued were ordered shipped to them, and the work at Boston, Philadelphia and Baltimore was ordered expedited. By the summer of 1796 a portion of the guns were received, proved and accepted.

It appears also that the action of Congress in discontinuing the work on three of the frigates cut off at the same time the pay of Captains Dale, Seaver and Talbot, of Naval Constructors Fox, Cheeseman and Hackett, and of Naval Agents Blagge, Pennock and Sheaffe. The officers at these places were directed to make suitable provision for the proper storing of such timber and materials as were not perishable and for the protection of the keels and frames of the three ships. Naval Constructor Fox was directed to visit the yards at New York and Portsmouth, N. H., to inventory the materials and inspect the arrangements which had been made for the proper preservation of the work already done.

The letter-book, in August, 1796, contains the first mention of the building of a frigate "for the Mediterranean service." Proposals were asked for a 36-gun frigate and Mr. James Hackett, of Portsmouth, N. H., appears to have been the lowest bidder. He was accordingly awarded the contract on condition that the vessel be delivered complete in ten months; that the Government would furnish the timber, plank, etc., which it had in store, at a valuation, and that the United States should appoint an inspector of the work. This frigate was, under the agreement with the Dey of Algiers, destined as a part of the price which the United States agreed to pay

to insure the safety of our commerce. The Secretary of the Treasury estimated the whole expense of fulfilling the treaty at $992,463.25. The cost of the frigate included in this sum was put at $99,727. To build this frigate much of the timber destined for the three vessels which Congress had decided not to continue, and which had been procured after many difficulties from the finest stock in the country, was sent to Portsmouth by direction of the Secretary of War.

The first mention of the famous figurehead of the vessel afterwards named the Constitution is found in a letter from the Secretary of War to the Secretary of the Treasury on September 20, 1796, in which he says:—

"Mr. John Skillen of Boston has been mentioned to me by Mr. Rush as a qualified artist to undertake the carving of the head or figure for the frigate building at that town. As it is proper that this work should be immediately commenced, you will be pleased to give such orders as may be necessary on the occasion. There is a drawing of the figure (a Hercules) now preparing which I shall send forward to Mr. Skillen as soon as finished."

An interesting sidelight on the proving of guns is given in a letter of September 27. The Secretary of War writes:—

"I believe the best explanation relative to the proving by water will be to give Mr. Hughes a more detailed view of the mode in which the experiment will be directed to be made. The object of the water proof is to discover whether there are any holes which penetrate through the sides of the cannon. For this purpose the examiners will be instructed, after the cannon have undergone the proof by powder, to place them upon a thick piece of timber so as they may be easily made to turn upon it. The touchhole will be stopped with a wooden peg colored with tallow. The cannon will then be raised, and the chace surrounded with linen, so that any water which may fall down the sides on filling the bore shall not be confounded with the drops that may filter through the metal, and with the same view the water will be poured into the cavity by means of the spout of a watering pot. The water will be then pressed upon by a rammer covered with thick cloth so as to fill exactly the muzzle of the cannon. During this operation the exterior will be attentively watched to see whether any water passes through the metal. If the least filtration appears, the cannon will be refused."

It is perhaps not surprising that the early records of our army and navy show many gun explosions.

In November, 1796, the Secretary of War urges Naval Constructor Stodder, at Baltimore, to push the work with more expedition, as the other two frigates show greater progress.

I have been unable to find any data showing how the first frigates came to receive their names. The letter-book is silent on this subject and the first mention

appears to be in the report of Representative Parker from the Committee of the House on January 25, 1797, in which mention is made of "The frigate building at Philadelphia, of 44 guns, and called the United States," "the frigate building at Boston called the Constitution of 44 guns," "the frigate Constellation building at Baltimore of 36 guns." It would be of great interest to discover who was responsible for the selection of these names, but it is probable that it was done by President Washington himself.

The report of the Secretary of War, James McHenry, to Congress in January, 1797, states:—

"The measures that have been taken to prepare the rigging and sails and to procure the necessary stores, and the advances made towards the final equipment of the frigates render it probable that they may be got ready for sea in about two months after being launched. While on this subject permit me to observe that if Congress perceive advantages in the extension of their marine or think it expedient that early precautions should be taken to secure to the United States a lasting fund of live oak for future use, it will be proper that authority should be given for the purpose, as well as to purchase a site for a navy yard. The probability is that an article so important to maritime nations as live oak will be sought after with much avidity; and that the land which is clothed with it may pass into hands that may make its attainment hereafter more expensive if not impracticable."

It may be of interest to note that out of the appropriation of 1799 the Navy Department purchased the sites for the navy yards at Gosport (now Portsmouth, Va.), Washington, D. C., Philadelphia, Brooklyn, Charlestown, and Portsmouth, N. H., and at the same time acquired Groner's Island, 350 acres, and Blackbeard's Island, 1,600 acres, for the purpose of obtaining a permanent supply of live oak. These lands are at present still owned by the Department.

The Secretary of War made the following statements of the progress made in building the three frigates up to January, 1797:—

U. S. S. UNITED STATES, 44 GUNS, BUILDING AT PHILADELPHIA.

"The hull is all planked inside and out and all the principal decks are laid and caulked, excepting a part of the gun deck. The upper deck beams are in and a part of them kneed; about half of the bottom is dubbed off and a considerable part caulked; the braces and pintles for the rother are all cast; the knees of the head together with the figure are nearly ready; all other parts of the hull are in such forwardness that it is expected she may be launched by the beginning of April next, provided the winter does not prove severe. The rigging is all made and nearly fitted; the yarns for the cables are spun; the anchors and iron ballast on hand; and the blocks, dead-eyes, water-casks, boats, lanthorns and all the tin work are provided. The other materials are in part procured and the work in general progresses rapidly towards completion."

U. S. S. CONSTITUTION, 44 GUNS, BUILDING AT BOSTON.

"The whole of the frame is raised and is ready for planking. The wales are prepared and it is expected will be on and fastened this month. The keelsons are in their places and bolted off. The masts are now on hand and the boats are building; all the dead-eyes for lower and topmast on shrouds are made and stripped; the knees for all the decks are procured as well as the beams, carlings, ledges, etc.; iron ballast sufficient is in store; and the necessary materials for completing the hull are procured and received. The hemp for the cables, rigging, etc., and blocks are in the hands of the respective tradesmen manufacturing; and if the winter should prove favorable there is no doubt but this ship may be launched in July next."

U. S. S. CONSTELLATION, 36 GUNS, BUILDING AT BALTIMORE.

"The whole of the frame is raised, the wales, black-strakes, flush, quarter and fore drifts on and dressed off; the ceiling, clamps for gun, lower and orlop decks are all in and dubbed off; the beams are prepared and ready to be put into their respective stations; the bottom is now planking and the knees are getting ready for the decks; other parts of the hull are progressing as fast as the workmen can be employed to advantage, and from present appearances this ship may be launched in May next. The lower, topmast and topgallant shrouds with all their respective stays are fitted and ready to go over the mastheads. The other rigging is also in great forwardness. The boats are all built, the water-casks mostly made, together with the blocks, dead-eyes, hearts, etc., etc. The cannon for the gun deck are all in the navy yard, trimmed, and are ready for mounting in the carriages which are made."

The following sums were estimated as being necessary to complete the frigates:—

U. S. S. United States	$55,950.00
U. S. S. Constitution	96,571.71
U. S. S. Constellation	47,375.00

It was also stated that the Department had sold perishable materials originally acquired for the other three frigates for a total of $4,214.05.

The work of completing the three frigates continued during the winter and spring of 1797. On April 17 the Secretary of War wrote to Naval Constructor Stodder at Philadelphia expressing his surprise that the Constellation could not be launched until July and urging him to use all possible expedition and "at the same time to be as frugal as possible in every part of the business."

The letter-book has the following interesting entry:—

"The frigate United States, of 44 guns, was launched from Mr. Joshua Humphreys' yard (Southwark), Philadelelphia, Wednesday, May 10, 1797, at fifteen minutes past one o'clock p.m."

On May 23 the Secretary of War writes to General Henry Jackson, the naval agent at Boston:—

"It may be proper that you should be informed that I am desirous each of the frigates shall be furnished with both suits of sails of this country manufacture."

On June 16 Secretary McHenry communicated to Congress the following statements in regard to the state of forwardness of the three frigates and of the further sums necessary to complete them:—

U. S. S. UNITED STATES.

"The hull of this ship was launched on the 10th of May last. The bottom is completely coppered; and the carpenter's work is nearly finished and she will be soon in a situation to receive her masts and stores. Several of the masts, yards and caps are finished and the remainder are under way. The boats are in hand; all the rigging, blocks, dead-eyes and one suit of sails are prepared; all the principal, and most of the small stores are provided, and the captain reports that the ship may be rigged and completed for sea in one month after the guns and lower masts are on board."

U. S. S. CONSTITUTION.

"The bottom of this ship is squared off and the caulkers are at work. The various decks are lain; the breastworks, diagonal riders and counter timbers are all in and secured, and the mast makers are employed on the masts and yards. All the boats excepting the pinnace are built. The riggers are at work on the rigging which will be soon ready, the water-casks are in hand, sails are preparing, and the constructor reports the ship may be launched about the 20th of August next. The captain is of opinion she may be completely equipped in one month after."

U. S. S. CONSTELLATION.

"The latest report states that this ship is in great forwardness. The bottom is caulked and finished, the lower deck is laid, and the other decks are in a forward state. The head, quarter galleries and stern are partly done, and the bowsprit is almost ready to be put on board. The materials for the equipment and rigging are all procured, one suit of sails is made and all the guns for the gun deck are in the navy yard and mounted on their carriages. The constructor states that this ship will be launched next month, and from the forward state of the masts, yards and

rigging, together with the other equipments, there is reason to conclude she can be completely fitted for sea in one month after she is launched."

These estimates of the further sums necessary to complete were added:—

United States, at Philadelphia	$64,820
Constitution, at Boston	93,470
Constellation, at Baltimore	79,414
Total	$236,704
Balance unexpended of last appropriation	$40,068
To be provided	197,636

During this summer the letter-book contains many entries relating to the purchase of equipment and stores for the three ships, as well as for the frigate building under contract at Portsmouth and destined as a present to the Dey of Algiers. On July 7, the Secretary of War writes to Capt. T. Thompson who had been employed to take the ship out to the Mediterranean:—

"It being necessary to fix on a name for the frigate intended for the Dey of Algiers before she sails from Portsmouth, I have, therefore, concluded to call her the Crescent, which name you will be pleased to have inserted in her papers and other documents. I have just received your favor of the 29th ultimo and I congratulate you and Mr. Hackett on the safe launching of the frigate into her proper element."

Congress, in June, 1797, passed a bill for the completing and manning of the three frigates. It will be remembered that for some years the merchant vessels of the United States had been subjected to vexations and spoliations committed by corsairs and privateers of several of the European countries. The French in the West Indies were the worst offenders, though there were many instances of the seizure of our ships by the British and Spaniards. The public documents of the period abound in references to these troubles. President Washington on many occasions called the attention of Congress to these depredations and his successor, President Adams, told Congress that a navy establishment would afford the only adequate protection. Hence it is not surprising that we find the Secretary of War using every effort to place the three frigates in commission and showing exasperation at the continued delays, especially in the case of the Constellation building at Baltimore. Some difficulty appears to have arisen over her launching, and Naval Constructor Humphreys was ordered to Baltimore to assist Constructor Stodder in making safe preparations. The frigates Constitution and Constellation were ordered coppered before launching. Meanwhile the United States, which had evidently received some slight damage in launching, had been repaired and was lying in the stream taking on board her guns. Captain Barry was ordered to obtain a crew and

the riggers had nearly completed the rigging. "Unfortunately," writes the Secretary, "all further progress was impeded by the contagious fever which attacked several of the officers and crew that were on board; several of the tradesmen employed in the equipment were also from the same cause prevented from attending to their respective occupations until the latter end of October, when it was found to be too late in the season to get the ship in complete order to meet a winter at sea. The Constellation was launched at Baltimore on the 7th of September and was anchored in the Patapsco to receive on board her stores, officers and crews."

The Secretary of War writes on September 10, 1797, to Naval Constructor Claghorne at Boston:—

"I received your letter of the 4th instant yesterday informing me of the present state of the frigate Constitution, and submitting the propriety of launching her during the high tides of the present month, noticing at the same time that the work which must be done after getting her into the water could be cheapest performed while on the stocks. If in your opinion it would be unsafe to trust to the tides in October I very readily agree to her being launched in this month; but if we may venture the delay until October and it would be a saving in point of expense I should prefer it, especially as it does not appear to me that anything could be gained by a premature launch to counterbalance the expense."

Accordingly the Constitution was launched at Boston on the 21st of October and was reported in December as ready for service early in the ensuing spring.

The following letter from Naval Constructor Claghorne to the Secretary of War gives a brief account of the previous attempts to launch the Constitution:—

"Having before stated to you my intention of launching the frigate Constitution on the 20th instant (September, 1797), the necessary preparations were made to that end, and at the time appointed all blocks and shores were removed with full expectation of her moving gently into the water. She, however, did not start until screws and other machinery had been applied; and then she moved only about 27 feet. * * *. I found that the part of the ways which had not before received any of the weight had settled about half an inch * * *. The next day after due preparation the ship was raised two inches * * *. Her bilge ways were then taken out and the apparent defects removed. All things being in order a second attempt was made on the 22d instant and upon the removal of her supports she moved freely for about 31 feet and then stopped * * *. On examining the ways erected on the new wharf I found they had both settled abaft about 1⅝ of an inch; which circumstance, as it could not have been foreseen, the descent of the ways was not calculated to overcome * * *. I am fully confident that the next trial on the high tides in October will be attended with success."

Congress met again in November, 1797, and in the following month the Secretary of War reported that the following additional sums would be necesary to complete and equip the frigates for use:

United States	$23,557
Constitution	26,275
Constellation	22,319
Total	$72,151
Balance of last appropriation unexpended	$35,554
Additional appropriation required	36,597

This was exclusive of the cost of the military stores and all the maintenance cost of the vessels when placed in commission.

On March 19, 1798, the President sent to Congress a message dealing with the increasingly strained relations with France and reiterated his recommendations for the adoption of measures for the protection of American commerce. On March 27, 1798, Congress appropriated $115,833 to complete and equip for sea the frigates United States, Constitution and Constellation, and $2,200 to defray the salaries of persons having charge of the yards at New York, Norfolk and Portsmouth where the uncompleted ships were lying. On March 8, a committee of the House of Representatives recommended the creation in the War Department of an office which should be employed in the immediate superintendence of the navy concerns of the United States, the officer in charge to be called The Commissioner of Marine.

In an interesting and exhaustive report to Congress on March 22 the Secretary of War reviews the construction of the ships. He states that various considerations, such as the rise in the price of labor and materials, the loss of two cargoes of oak in its passage from Georgia, the loss of hemp by fire in Boston, the cost of an additional wharf to insure the safe launching of the frigate United States, the expense of heaving down the United States to repair an injury done to her false keel and rudder braces by striking the ground in launching, the expense occasioned by repeated trials in attempts to launch the frigate Constitution, the expense of double freight in removing some of the live oak and other timber from one yard to another, were among the causes of the difference between the estimated and the real cost of the armament. He continues:—

"The frigates are now nearly finished and from the best judgment that can be formed respecting them, promise to prove the most complete of their kind that have appeared on the ocean; and such as would do credit to the most skillful workmen of countries more experienced in naval architecture than ours * * *. If the United States contemplates an arrangement for properly providing naval protection to their commerce, suitable to the resources of the country and its relative situation to

foreign powers, the marine business in such a case ought to be separated from the Department of War or the Department of War enabled by proper institutions to conduct it in a manner more conformable to the practice of other nations."

On April 30, 1798, the office of the Secretary of the Navy was established by law. Benjamin Stoddert, of Georgetown, was appointed to the office. The records of the Department contain nothing to show when the Constitution, United States and Constellation were actually ready for sea. Secretary Stoddert on taking office found them practically in a state of readiness. The year 1798 was the beginning of the quasi war with France. The United States, Capt. John Barry, was ordered to sea in July. Captain Truxton was ordered to sea in the Constellation on the 10th of August, and the Constitution, Captain Nicholson, was ordered to patrol the coast on the 13th of August.

These are a few of the features of the building of the first ships of the Navy of the United States. Their records throughout the years have been a monument to the men who planned them, the men who built them, and the men who manned them. All of them became victors in battle—the Constellation in the actions against the French frigates Vengeance and Insurgente, the United States in the victory over the British Macedonian, and the Constitution in the capture of the British Guerriere, Java, Cyane and Levant. Two of the three, the Constitution and the Constellation, are proudly carried on the rolls of the Navy to-day, one hundred and seventeen years after their launching. May they long continue as a living inspiration to the nation.

DISCUSSION.

THE CHAIRMAN:—Is there any discussion on this interesting paper prepared by Secretary Roosevelt?

REAR ADMIRAL WASHINGTON L. CAPPS, U. S. N.:—At the request of the Acting President I was in communication with Secretary Roosevelt by telephone last night, and he expressed his very great regret at his inability to remain over and be with us to-day, not only to present his paper, but also to join us at the banquet to-night. Imperative engagements in Washington, where the Navy Department is now presenting certain information to the Naval Committee, made necessary his return to that city on the midnight train. He desired that his great regret at his unavoidable absence be conveyed to the membership of the Society.

This paper is one which hardly lends itself to discussion. It is more in the nature of a "human interest" document. I feel quite sure that no paper presented at this meeting has greater human interest than the one prepared at such pains by the Assistant Secretary of the Navy. He has embodied in this comparatively brief paper much data that intimately relate

to work now being done by members of this Society. Knowledge of history in all its phases is useful in determining lines of conduct, and even in matters material, such as shipbuilding, we can profit much by reading of the exploits of those who have gone before. I think the experiences of other days ought surely to give us encouragement in our work of to-day. We are all quite familiar with the cynic's criticism, that "things are going to the bow-wows," as it were, and conditions are getting very much worse. Historical research, however, furnishes good evidence that conditions are getting constantly better. I recall reading some years ago an account by a noted Italian archæologist, who described some of the difficulties of the time of Michael Angelo when it was found that certain contractors had been in the habit of taking pay for the highest grade of material and putting in the very cheapest material that they could get past the inspector. Those particular contractors, when they were detected, were visited not only with pecuniary, but with other punishment, but it shows that such practices are not of recent origin.

I also note with interest that General Knox, the Secretary of War, said: "I should find great satisfaction in a contract if one upon solid price could be obtained." That statement was quite prophetic, because you will note there were several additional estimates submitted and additional sums asked for to relieve the Government and the contractors from the dilemma into which they had fallen.

At foot of page 142 allusion is made to the vessels as follows: "It was contemplated to make them the most powerful, and at the same time the most useful ships." That statement, written more than one hundred years ago, has been typical always of the efforts of our naval designers and those who subsequently command the ships—that is, to have the most powerful batteries, and to have the most secure fighting platforms obtainable. In the naval wars in which this country has been engaged, superiority of battery has always been a very distinguishing feature.

At foot of page 148 there is a little ancient history which is interesting to us even at this date. Of course these vessels were very ambitious vessels for their day, and were to have been completed within a comparatively brief period. Year after year passed by, and it took about four times the time originally estimated. Unexpected delay has been somewhat our own experience—not so exaggerated, of course, within the past thirty years. However, for more than ten years past we have been building almost as rapidly as any other country in the world. In the third paragraph on page 149, there is something which is especially significant. It says: "It may be proper that you should be informed that I am desirous each of the frigates shall be furnished with both suits of sails of this country manufacture." That is a sentiment expressed more than one hundred years ago, which is very much in the minds of all of you at the present time, a sentiment which I know appeals to every one in this country, regardless of political affiliations.

As a whole, gentlemen, the paper is well worthy of careful perusal, and I feel entirely sure that you will authorize the President of the Society to convey your thanks to the Assistant Secretary of the Navy for his painstaking care in preparing for us this most admirable record of what took place more than one hundred years ago. (Applause.)

Naval Constructor J. G. Tawresey, *Member*:—This paper, based on one of the earliest chapters of the history of the Navy, is most interesting, and it contains lessons and instructions that are applicable to-day. Admiral Capps has referred to some of the features, the difficulties with estimates and the matters of delay. They are difficulties that are still encountered and are probably inseparable from the operation of shipbuilding.

It is part of my duty at the present time, when at the end of any month the vessels under construction have not made the progress expected, to make a report to the Department and to assign reasons for the delay, and I assure you that it is sometimes difficult to assign a reason satisfactory to myself, satisfactory to the builder, and satisfactory to the Department. My inventive ingenuity has frequently been taxed along that line, but on page 142, I note reasons that have never occurred to me and have never been embodied in one of my reports, namely, that the timber had to be cut and the flax had to be grown.

THE CHAIRMAN:—Any further discussion? If not, in accordance with the suggestion of Admiral Capps, the Society will tender its thanks to Secretary Roosevelt for his valuable and interesting addition to our Transactions.

We will now have the moving pictures showing the launching of the Oklahoma.

The moving pictures were thrown on the screen, after which the meeting adjourned until two o'clock.

FOURTH SESSION.

FRIDAY AFTERNOON, DECEMBER 11, 1914.

Rear Admiral Capps called the meeting to order at 2.15 o'clock.

THE CHAIRMAN:—Our Acting President had to be away this afternoon, and requested me to take the chair in his absence. The first paper this afternoon will be No. 10, "Refueling of Warships at Sea," by Mr. Spencer Miller, Member.

Mr. Miller presented the paper.

REFUELING WARSHIPS AT SEA.*

By Spencer Miller, Esq., Member.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

In 1883, Admiral R. S. Lowry, K. C. B., R. N. (senior officer on coast of Scotland, stationed at Rosyth 1914-1915), then a lieutenant, read an essay on "Coaling Ships or Squadrons in the Open Sea" before the Royal United Service Institution of London. To show the necessity for improved apparatus for coaling warships at sea he said:—

"I think I am within the mark in stating that during the blockade of Charleston by the Federal fleet, nearly one-quarter of that force were always absent from before the port employed in filling their coal bunkers."

The efficiency of the blockade before Charleston was, therefore, numerically considered, about 75 per cent.

The year 1914 witnesses three important blockades: the British in the North Sea since August 4, the British-French in the Adriatic Sea, and the Japanese at Kiao Chau Bay from August 23 to November 7. The Japanese maintained their blockade for eleven weeks and were successful. At the present* writing the blockade in the North Sea has been maintained for twenty-three weeks and in that period each ship has replenished its bunkers at least sixteen times.

Blockades are not obsolete, although the method of blockading has undergone a change since 1883. We can only conjecture as to their efficiency.

Admiral Lowry added:—

"During the same war (U. S. Civil War) Federal cruisers while searching for the Alabama were constantly obliged to quit that portion of the sea allotted to them in order to fill their bunkers, after one or two useless chases after suspicious looking vessels."

Since August 1 ten German cruisers and several converted merchantmen have played the part of the Alabama. They have captured or sunk nearly 100 merchant ships. These German cruisers are the—

Emden, 3,600 tons, speed 24½ knots (sunk November 9).
Karlsruhe, 4,900 tons, speed 28 knots.
Nurnburg, 3,450 tons, speed 23½ knots (sunk December 8)

*Corrected Jan. 1, 1915.

Dresden, 3,600 tons, speed 24½ knots.
Leipzig and Bremen, 3,250 tons, speed 23 knots (Leipzig sunk December 8).
Scharnhorst and Gneisenau, 11,600 tons, speed 20.5 knots (sunk December 8).
Geier, 1,630 tons (interned at Honolulu).
Koenigsburg, 3,348 tons, speed 23½ knots (bottled up at Mafia Island).

These ships are reported to have frequently coaled at sea.

Many British and French battleships and cruisers have been protecting commerce and chasing the German cruisers. Among these are the—

Bristol, Glasgow and Newcastle, 4,800 tons, speed 25 knots.
Suffolk, Lancaster and Cumberland, 9,800 tons, speed 24 knots.
Good Hope, 14,100 tons, speed 23 knots (sunk by Germans November 1 off Coronel, Chile).
Monmouth, 9,800 tons, speed 24 knots (sunk by Germans November 1 off Coronel, Chile).
Highflyer, 5,600 tons, speed 20 knots.
Swiftsure, 11,800 tons, speed 19 knots.
Canopus, 12,950 tons, speed 16.5 knots.
Invincible and Inflexible, 17,250 tons, speed 28.5 knots.
Kent and Cornwall, 9,800 tons, speed 24 knots.
Carnarvon, 10,850 tons, speed 22.1 knots.

In fact the British Admiralty announced that some seventy ships of the Allies were searching for the German cruisers. The Good Hope and Monmouth allowed their position to be known to the Germans by entering a harbor for coal. They were sunk later by the Germans.

In 1887 Lieut. C. E. Bell, R. N., before the same Institution, read a paper entitled "Coaling Ships of War at Sea." Lieutenant Bell said:—"I feel sure that all officers will agree with me that coaling from the broadside at sea is impossible except in very calm weather;" and, after describing many practical experiences, said:—"The only way by which the various difficulties of coaling at sea can be overcome is by coaling from bow to stern."

Lieutenant Bell's plan showed an incomplete reciprocating cableway like a breeches buoy apparatus. No compensating apparatus was shown.

Commenting on Lieutenant Bell's plan, Captain Fitzgerald, R. N., said, "It would fail absolutely," and added:—

"As to blockade, I think it is a thing of the past absolutely. You could not blockade in these days of torpedoes anywhere near the enemy's port."

Answering this, the late Rear-Admiral P. H. Colomb, R. N., said:—

"I sincerely believe that we are going to watch our enemy wherever they are, in spite of torpedoes or whatever it may be. Therefore, from my point of view, the question is of vast importance."

What Admiral Colomb said in 1887 might be said with equal force to-day, for the English are watching their enemy "in spite of torpedoes" and "the question (of coaling at sea) is of vast importance."

Admiral Colomb at the same time pointed to the advantages of oil fuel and the simplicity by which it could be transported at sea. Within the last few months Admiral Von Tirpitz, Minister of the German Marine, pointed to the great advantage of using liquid fuel and the ease with which warships can be supplied in a seaway.

Rear-Admiral Reginald G. O. Tupper, R. N. (then a lieutenant), agreeing with Lieutenant Bell that the "bow to stern" method was correct, suggested a continuous moving endless rope between collier and battleship, having bags of coal attached, transporting the same in a continuous stream to the battleship.

To-day the two surviving systems for coaling warships at sea are developments of Lieutenant Bell's plan for a reciprocating cableway apparatus, viz., the Lidgerwood-Miller marine cableway, and Rear-Admiral Tupper's plan for a continuous rope apparatus, viz., the Adam (German) endless rope coaling-at-sea gear.

BLOCKADE OF SANTIAGO.

In 1898 our fleet blockaded the Spanish at Santiago de Cuba, and who does not remember Commodore Schley's telegram to Rear-Admiral Sampson, U. S. N., dated May 24, 1898:—

"Coaling off Cienfuegos is very uncertain. Having ascertained that the Spanish fleet is not here I will move eastward to-morrow, communicating with you from Nicholas Mole; on account of short coal supply in ships cannot blockade them if in Santiago. I shall proceed to-morrow, 25th, for Santiago, being embarrassed, however, by Texas short coal supply, and our inability to coal in the open sea."

Commenting on the blockade, in 1900, Rear-Admiral Sir S. M. Eardley-Wilmot,* R. N. (Retired), in "Our Fleet To-day," said:—

"The method employed in this operation is the most noticeable feature of the war. Exponents (mostly civilians) of naval warfare have declared that steam and torpedo boats will render the blockade in modern warfare impossible and submarine attack would deter the blockading force from being effective. Sampson demonstrated that steam had made blockade more certain and the torpedo attack must be dealt with otherwise than by running away from it."

It is also a matter of record that while our fleet was blockading Santiago frequently one-fourth of our ships were absent for recoaling, and when the Spanish came out three of our ships (one the battleship Massachusetts, which cost the

*Author of "The Next Naval War," 1894; "The Battle of the North Sea," published 1912, and many other valuable works on naval warfare.

Government originally over $6,000,000) were 45 miles away, coaling at Guantanamo, utterly useless for fighting purposes.

JAPANESE BLOCKADE, 1904.

In 1904 Admiral Togo blockaded Port Arthur, while the attempt to blockade the Russians in Vladivostok failed. The author has the word of a Japanese naval officer on board the Japanese blockading ships before Vladivostok that the only reason they failed to bottle up the Russian cruisers was because they were unable to coal their ships in a seaway.

LIEUTENANT DEWAR'S GOLD MEDAL PRIZE ESSAY.

Lieut. A. C. Dewar, R. N., in his Gold Medal Prize Essay before the Royal United Service Institution in 1903, dwelt exhaustively upon the subject of blockades. He pointed to the doubtful value of attempting a blockade should the base of supply be too remote. He gave two striking examples of blockading the port of Toulon with 12 Implacables. In the first instance, the ships of the fleet were to be recoaled at Malta, 550 miles distant; in the second at Pollenza Bay, 154 miles distant.

When coaling at Malta, 550 miles distant:—

Each of the 12 Implacables would remain on blockade.....	10.5 days.
Each ship would be absent for coaling.....	5.8 days.
The efficiency of such a blockade would be about	64%

When coaling at Pollenza Bay, 154 miles distant:—

Each ship would remain on blockade.....	15.5 days.
Each ship would be absent.....	3.1 days.
The efficiency of the blockade becomes.....	83%

In the best example 12 Implacables are assigned for blockade duty while only 10 ships remain continuously on blockade. Two extra Implacables, costing $10,000,000, must be assigned because of the inability of the 10 ships to refill their coal bunkers at sea. No navy in the world can better afford such extravagance than the British with their 635 ships.

BRITISH NORTH SEA BLOCKADE, 1914 AND 1915.

To-day we find the British Navy blockading the German fleet in the North Sea. This blockade has been effectively maintained for more than twenty-three weeks. Submarines and destroyers are doubtless stationed not far from Helgoland. Scout and other light cruisers are distributed to form a support for the destroyers and connecting links with the battle fleet. Armored cruisers are doubtless distributed

in accordance with their speed and fighting power, partly as a direct support for the lighter ships, partly as reserves in the rear. The battle fleet is hidden away as safe as possible from submarine attack. It may or may not be at sea.

Great Britain was said to have 110 cruisers in the North Sea. Five have been destroyed by submarines. Fifteen new cruisers will be ready within a few months. Great Britain is reported to own 232 destroyers and 20 building. She also has 75 submarines. Perhaps half of the destroyers are employed on blockade duty in the North Sea.

All the ships are either fueling at sea or leaving the blockade (perhaps every ten days) for the smooth waters of English harbors for refueling. Several have been reported coaling at Harwich.

Every time a cruiser retires from the patrolling line of the blockade to a shore base for refueling, the blockade is materially weakened, for the absent ship is temporarily useless for fighting purposes, to say nothing of the danger of destruction by submarines, lying in wait on the route to and from the coaling base.

England has an abundant supply of cruisers at present and can afford to allow 15 per cent or 20 per cent of these ships to be absent from the blockade filling their bunkers; nevertheless, the efficiency of that blockade is materially weakened whenever the cruisers are withdrawn for refueling. So far as destroyers and submarines are concerned, these are frequently relieved from blockade duty to refresh the personnel and the time consumed in refueling need not be time lost. If necessary to change crews on light cruisers, transports could be used; this would allow each cruiser to stay on duty continuously or nearly so.

COALING WARSHIPS IN THE NORTH SEA.

By way of example, suppose the British employ 100 cruisers for blockade duty in the North Sea, costing an average of $2,000,000 each. This would represent a total investment of $200,000,000. Practically all burn coal. Considering the distance to shore coaling ports, it is difficult to believe that more than 85 per cent of these cruisers are maintained on blockade duty unless they refuel at sea. Fifteen per cent of these ships absent coaling at a shore base represent a temporary weakening of the blockading fleet of 15 ships, worth in money alone fully $30,000,000. This blockading fleet of 100 cruisers could be maintained close to 100 per cent efficiency if served by colliers equipped to deliver coal to them under all reasonable conditions of the sea.

Does not this illustration serve to indicate the value of mastering the art of refueling warships in a seaway? The U. S. colliers Jason and Orion, carrying 12,000 tons of coal, equipped with high-speed broadside coaling gear as well as marine cableways to coal a warship in tow, would be ideal for North Sea service. Such colliers could deliver to a cruiser in tow 500 tons of coal in the daylight hours, steaming at 10 to 12 knots while doing so. When submarines are present ships must keep moving at a speed of 10 knots at least. With 100 ships on blockade duty, burn-

ing 50 tons per day each, each should be recoaled about once in 10 days, and 10 ships would be coaling every day. It is true that on the infrequent days of violent storms, when the sea becomes exceedingly rough, these cruisers could not receive coal by any method, and the colliers would be temporarily idle. Under normal sea conditions every collier could deliver coal every day and thus be working to its highest capacity and efficiency.

BIG COLLIERS INCREASE THE EFFICIENCY OF COALING.

The bigger the collier and the better the broadside coaling gear the oftener it can be used for broadside coaling under headway in smooth seas. Furthermore, the bigger the collier the steadier it is for handling coal along the decks when delivering coal in a heavy seaway. It must be understood, however, that any collier can be equipped with a marine cableway for coaling in a seaway.

The British Admiralty experimented for years to find or develop a suitable sea-coaling apparatus to be wholly carried by battleships and cruisers. None appreciate the value of refueling warships in a seaway more than the British Admiralty. They have mastered the art of oil bunkering at sea, but the apparatus is carried on their own oil tank ships. The British Admiralty has never built a fleet of naval colliers. Colliers carrying coal to British warships are privately owned and are chartered, as needed, by the Admiralty. The author has never heard of any privately owned collier being equipped with coaling-at-sea apparatus, except experimentally.

It is for these reasons that the author believes that the cruisers in the North Sea are coaling chiefly at shore bases or at sea when sea conditions permit colliers to come alongside. The efficiency of the patrolling fleet must be low in rough weather.

COALING BRITISH COMMERCE PROTECTING CRUISERS.

An extraordinary demonstration of sea power is exhibited by Great Britain placing fast cruisers to protect English shipping on the Atlantic Ocean. Several British cruisers are protecting the lanes of travel between Great Britain and the United States. These cruisers could coal on the British coast, at Halifax and at Bermuda. Halifax is about 200 miles distant from the popular transatlantic routes and Bermuda nearly 600 miles.

It is always important that bunkers be kept as full of coal as possible. Many of these ships coaled at Halifax. When one of these cruisers leaves the lane of travel it becomes temporarily useless for the purpose assigned. To steam 200 miles, coal and return, would consume the better part of three days and is time lost. The trip halfway across the Atlantic and back at economical speed would be about nine days. Assuming that three days out of twelve be lost in coaling, the efficiency of such a ship would be about 75 per cent.

Generally speaking, therefore, it appears that the efficiency of such a fleet of

commerce-protecting cruisers would be greatly enhanced when served by colliers capable of delivering coal in a seaway. In time we may learn that these cruisers did coal near the American coast from colliers alongside when the sea was smooth enough to permit.

THE INFLUENCE OF THE SUBMARINE ON THE COALING PROBLEM.

The year 1914 witnessed the triumph of the submarine and the automobile torpedo. It has already been demonstrated in English maneuvers that the submarine finds its victims by lying in wait in the vicinity of the known coaling ports of the enemy. The author believes that when all the circumstances connected with the sinking of the British ships in the North Sea come to light it will be found that some of these vessels were sunk either on their way to or from their coaling base. The triumph of the submarine seems to indicate that the safe place for refueling is on the high seas.

Where submarines are present it is necessary for warship and collier to steam ahead continuously at not less than 10 knots. This adds enormously to the difficulties of coaling broadside at sea. It makes it impossible to coal from small boats at sea. Recognized defense against submarines is not only speed but a continuous change in direction. This again adds to the difficulties of broadside coaling, for even though a sea might permit two ships to steam alongside at 10 knots, if steaming head-on into a sea they might not do so in the trough of the sea. All of this is permissible in connection with any practicable cableway system of coaling at sea.

Sir Percy Scott regards battleships obsolete because of the perfection of the submarine and the automobile torpedo. No navy has ceased to build battleships. Naval constructors everywhere are endeavoring to determine the most practicable way of constructing a battleship with defensive qualities against the torpedo. The ordinary double bottom is no longer sufficient protection against the torpedo. The plan which apparently presents the most practicable advances is complete under-water armor. It will be a serious matter for a battleship to carry the weight of the necessary extra armor unless the bunker capacity of the battleship is largely curtailed. To largely curtail the bunker capacity of a battleship is a matter of serious moment unless the art of refueling at sea is mastered.

COALING AT SEA BY GERMANY.

The German Admiralty have always shown the keenest interest in the problem of coaling their cruisers on the high seas, His Royal Highness Kaiser Wilhelm II showing great personal interest in the problem.

Perhaps the first paper read before a scientific body in Germany on this subject was that written by William H. Beehler, Commodore U. S. N., Naval Attaché at Berlin. This was read before the Shipbuilding Society in 1902. It described the author's first marine cableway, which in 1899 transported coal at sea

from the collier Marcellus to the battleship Massachusetts. The German newspapers described the apparatus at length and appealed to German engineers to produce a successful apparatus. One such article (Die Zeit Wien, Vienna, October 1, 1903) closed as follows:—

"In case of an introduction of apparatus of their own construction the German Navy would become independent of foreign countries and at the same time enrich home industry, being material profit, for the Spencer Miller contrivance costs per ship about 64,000 marks. As it is probable that all line vessels and large cruisers would be equipped with it there would be (in case this question were solved by German engineers) a large sum of money to be saved for the German industry, which would otherwise go to foreign lands."

This appeal, which doubtless emanated from the German Admiralty, was responded to by several devices, two of which were thoroughly tested at sea. The financial backers of each device claimed to have expended between $175,000 and $200,000 in carrying forward the development of their coaling-at-sea appliances.

The first was set aside. The Adam apparatus was adopted. The German Admiralty demanded an apparatus that could transport 50 tons of coal per hour in a moderate sea, the entire apparatus to be suitable for carrying on a cruiser or battleship. The German Admiralty has also insisted that any apparatus for transshipping coal at sea must take coal from captured merchantmen or colliers.

The cruiser Roon, 9,050 tons, was equipped with the Adam apparatus, and succeeded in delivering an average of 62 tons per hour over a period of ten hours. The apparatus was tested under severe sea conditions when the collier and cruiser rolled at least 15 degrees.

The Adam apparatus was first manufactured by Felten & Guilleaume-Lahmeyerwerke Actien-Gesellschaft, Frankfort. It involves the employment of a continuously traveling endless rope bending around a series of fixed pulleys on both warship and collier. A movable pulley on the warship is connected with an automatic tension winch for taking up and paying out the cable as demanded by the motion of the ships.

The company manufacturing the Adam apparatus was bound by secrecy not to divulge the number of coaling-at-sea apparatus sold, nor the ships which were equipped with the apparatus, and for this reason the author cannot give any information respecting the equipment of the German cruisers with the Adam apparatus.

COALING GERMAN CRUISERS.

The authorities in charge of supplying coal to German commerce-destroying cruisers have done their work thoroughly and efficiently. During the period of fourteen weeks each of these cruisers must have been recoaled at least seven times.

The German cruisers Emden, Karlsruhe and Dresden and the converted Ger-

man liner Kronprinz Wilhelm are said to have taken coal from captured colliers. Other German cruisers are said to have received coal from ships sent out from New York, Philadelphia, San Francisco, Havana and Manila. We hear that the wireless was brought into play between shore stations and the German cruisers, also between the colliers and the cruisers.

Several of these German cruisers are reported to have coaled alongside in the sheltered waters of islands. The British Admiralty issued a statement early in October, prompted by the destructive work of the German cruisers Emden and Karlsruhe, as follows:—

"The vast expanses of seas and oceans and many thousands of islands offer almost infinite choice of movement to the enemy's ships. In spite of every effort to cut off their coal supply it has hitherto been maintained by one means or another. In the face of increasing difficulty the discovery and destruction of these two enemy cruisers, therefore, is largely a matter of time, patience and good luck."

The Emden was caught destroying a wireless station and sunk November 9; the Karlsruhe is still at large (January 1, 1915).

COALING FROM CAPTURED COLLIERS.

The British steamer Indian Prince was captured by the converted German liner Kronprinz Wilhelm off the Brazilian coast on September 4. The commander of the Kronprinz Wilhelm made the Indian Prince steam for five days, when sea conditions permitted the German cruiser to come alongside. They made fast, put aboard a gangplank and transferred about 130 tons of coal, stores and provisions. Coaling began on the afternoon of September 8. The crew worked all night until 10 o'clock on September 9, when she cast loose and sank the British ship.

The British steamer Holmwood was captured by the German cruiser Dresden. The rescued sailors say: "The commander of the Dresden first ordered the crew of the Holmwood aboard the cruiser, then took coal from the steamship and sank her by firing twenty shells."

The Emden was coaled from the German steamer Markomannia in the smooth waters off Sumatra Island, and from the captured British ship Exford, which was finally sunk. As the Emden's field of operations was in the Indian Ocean, south of which hundreds of islands exist, doubtless she never coaled otherwise than broadside in smooth waters.

The German cruiser Karlsruhe was discovered taking coal from the Kronprinz Wilhelm in midocean. The coal was being passed in small boats from ship to ship. When the British cruiser appeared both ships steamed away, leaving their small boats in the sea. The Karlsruhe claimed to have captured 15 ships since August 31, from which they have replenished their coal bunkers and kept their larder well stocked.

The collier Mazatlan, flying the U. S. flag, cleared from San Francisco for Guaymas, Mexico, August 13, under $20,000 bond to deliver her coal as consigned. North of Magdalena Bay the Mazatlan picked up the German cruiser Leipzig and transferred mail and stores to her. Her coal, however, was carried to Guaymas, where it was transferred to the German steamer Marie, which later coaled the Leipzig.

The Norwegian ship Helicon in Chilean waters was said to have been stopped by a German cruiser and compelled to give up her cargo of coal, the Helicon's port side being badly crushed in the process.

THE DANGER OF COALING IN PORT.

The *North German Gazette* (*N. Y. Sun,* October 30) gives the following story of the fight between the auxiliary cruiser Kaiser Wilhelm der Grosse and the British cruiser Highflyer:—

"On August 26 the cruiser Kaiser Wilhelm der Grosse lay in the Spanish harbor of Rio del Oro with two coaling steamers alongside, while a third German steamer lay at anchor about 500 meters further out. The entire crew had been busy coaling for two days. The bunkers were not yet half filled when toward noon a ship came in sight which turned out to be the English armored cruiser Highflyer. The following searchlight signals were then exchanged by the two ships:—

"Highflyer: Surrender! (No answer.)

"Highflyer: I call on you to surrender.

"Kaiser Wilhelm der Grosse: German warships do not surrender. I demand of you to observe the Spanish neutrality.

"Highflyer: You are coaling for the second time in this port; I call on you to surrender. If not I will fire on you at once.

"Kaiser Wilhelm der Grosse: I am coaling here for the first time. Besides, that is a Spanish affair.

"Highflyer: Surrender at once.

"Kaiser Wilhelm der Grosse: I have nothing more to say."

The above dispatch is valuable. It supplies some approximate data indicating that the Kaiser Wilhelm der Grosse was being coaled at the rate of 500 tons per day per collier. The marine cableway alone could deliver 500 tons per day on the high seas, where the cruiser would have been able to make her escape had she been discovered.

THE HIGH SEAS A SAFE PLACE TO HIDE.

The British cruisers Good Hope and Monmouth taking on coal at Coronel, Chile, furnished an opportunity for a wireless message to be sent to the German fleet, which, gathering in full strength, found these ships and sunk them (November 1) a day or so afterwards.

The German bark Margretha played hide-and-seek with hostile battleships for thirty-five days and finally landed safely in the Azores.

The German full-rigged schooner Indra was on the high seas continuously from the time the war broke out until she landed in New York early in November.

The German steamer Brandenburg sailed from Philadelphia on August 22, clearing for Norway with a cargo of 8,000 tons of coal and general ship supplies. Ample notice was given of the ship's intentions. Outside the Delaware Breakwater she transferred coal to a German cruiser and succeeded in eluding English cruisers all the way across the Atlantic and landed safely in a port in Norway.

JAPANESE BATTLESHIP HIZEN AT HONOLULU.

On October 22 a cable dispatch from Honolulu stated that the Japanese battleship Hizen (formerly the Russian battleship Retvizan) anchored in the roads awaiting the exit of the German cruiser Geier and said:—

"The Hizen appeared off the harbor late to-day fully coaled and provisioned, fourteen days out of Yokosuka, a naval depot near Yokohama."

This is of interest, for the battleship Retvizan carried a marine cableway operated by special electric winches, the installation and trials of which were fully described in the author's paper read before this Society in 1904. The test of this marine cableway (Fig. 2, Plate 59) took place in the Baltic Sea, August 30, 1902, near Cronstadt, Russia, under the direction of a Board of Inspectors, among whom were Admiral Nikonof, I. R. N., Chief of the Test Squadron, and Rear-Admiral Wirenius, I. R. N., Chief of Bureau of Navigation. The old auxiliary cruiser Asia served as collier. The sea anchor was used in this installation and, while seemingly successful on this battleship, is now regarded as obsolete.

AN APPEAL FOR COALING EFFICIENCY.

Capt. Albert P. Niblack, U. S. N. (then a lieutenant), in 1893 read a paper before this Society entitled "Coal Bunkers and Coaling Ships." Captain Niblack urged that rapid coaling was a factor in efficiency and said:—

"The efficiency in ship and crew must be supplemented by the best mechanical arrangements practicable and a ship must be able to *go* somewhere and *stay* there. Coal supply and rapid coaling are very important factors in efficiency not only in an emergency but in time of peace, for time spent in coaling ship is time wasted."

Captain Niblack appealed for improved coaling gear, larger bunkers, and for simplified arrangements to reduce the time for stowing. He showed that few of our ships averaged better than 30 tons per hour in coaling.

Enormous progress has been made since this paper was read. The United

States Navy leads in colliers and collier equipment for broadside coaling in smooth seas, as well as in cableway equipment for coaling from collier to warship in tow in a seaway.

Both have to do with increased coaling efficiency.

COALING THE U. S. S. WYOMING IN 1914.

The U. S. S. Wyoming coaled at Guantanamo Bay in the spring of 1914 from the U. S. collier Jason on one side and the U. S. collier Nereus on the other. Both colliers are equipped with the two most recent types of coal-discharging apparatus. Both discharge with clamshell buckets.

The Jason is equipped with twelve marine transfers, each operated by one winchman (see Figs. 5 and 6, Plate 61).

The Nereus is equipped with twelve special cableways, each operated by two winchmen.

Both colliers rigged out eight booms over the deck of the Wyoming.

The Jason used her eight booms continuously, dropping coal at eight different points along the deck and through the chutes of the Wyoming.

The Nereus used six to eight booms, intermittently, on account of breakages.

All was made ready for test the night before—time to get ready not given (usually 20 to 30 minutes' work on the Jason). Coaling began at 5.30 in the morning and stopped at 8 o'clock for breakfast, resuming at 8.30. The Jason cast off at 9 o'clock. The Nereus cast off at 9.30 o'clock. The Jason delivered to the Wyoming a maximum of 465 tons per hour. The Nereus delivered to the Wyoming a maximum of 433 tons per hour. The Jason delivered a total of 1,040 tons in 3 working hours, an average of 346 tons per hour. The Nereus delivered a total of 1,020 tons in 3½ working hours, an average of 292 tons per hour.

From 550 to 600 tons of coal were heaped on board when the colliers left, and it required from 9 o'clock in the morning to 4.30 in the afternoon to clear up and stow the coal left on board.

The whole operation of taking on and stowing 2,060 tons of coal was accomplished in 9½ hours, an average of 217 tons per hour.

Both the Jason and the Nereus coaling gears are able easily to discharge 100 tons of coal per hatch per hour.

In the official trial of the collier Jason 137½ tons of coal were actually discharged in one hour with one operator.

At the conclusion of the trial Admiral Badger expressed the opinion that the Wyoming could at any time take on 2,100 tons of coal in five hours from two colliers in smooth waters, stowing the surplus left on deck at leisure.

From the above it appears that from one collier the taking on and stowing of 2,100 tons of coal would require approximately ten hours, being an average of 210 tons per hour. The coaling rate in 1914 is therefore seven times faster than in 1893.

So far as colliers and coal-discharging gear are concerned, their development

has outstripped the stowing facilities on battleships. In the author's paper, "Coaling Warships from Colliers in Harbors," read before this Society in 1910, he pointed to the record of discharging, with the marine transfer, 190 tons of coal from one hatch of the collier Hector in one hour with two operators.

He also stated that in future marine transfers' capacity was to be sacrificed in the interest of economy of maintenance and operation, the new winches to be more rugged, as fool-proof as possible, and the control simplified so that each marine transfer could be operated by one winchman. It is gratifying to note that on the colliers Neptune, Orion and Jason all the conditions set forth at that time have materialized. It is unnecessary to have a discharging apparatus with a capacity greater than 100 tons an hour per hatch. It is wasteful of money to use more winchmen than are necessary.

MARINE CABLEWAY ON U. S. COLLIER CYCLOPS.

The marine cableway on the U. S. collier Cyclops comprises the following elements:—

1. A main trackway cable 1-inch diameter, 900 feet long, spanning from mainmast of collier to portable spar on quarterdeck of battleship.

2. An automatic tension engine with two 13-inch × 13-inch cylinders for taking up and paying out suspended cable, maintaining practically a uniform tension of 18,000 pounds.

3. A load carriage running on the main cable adapted to carry 4,000-pound loads.

4. A conveying rope in two parts, an inhaul rope ½ inch × 875 feet and an outhaul rope ½ inch × 1,625 feet, one end of each being attached to the load carriage.

5. Two high-speed automatic tension engines, each with two 10-inch × 10-inch cylinders for hauling the load carriage at a speed of 2,000 feet per minute and automatically maintaining the tension in the conveying lines when the carriage is standing still at either terminal.

6. Hauling down apparatus on the collier whereby the cable and load carriage are lowered for receiving the load.

7. Lowering apparatus on board the battleship whereby the cable and load carriage are lowered for delivering the load and receiving the empty bags.

The automatic tension engine, Fig. 9, Plate 63, in connection with the marine cableway, has entirely supplanted the sea anchor. It maintains the supporting cable at the requisite tension and deflection, independently of the speed of the ships. After the cableway is set up and the engine adjusted for the required tension, it needs no further attention, other than oiling, throughout coaling operations.

Fig. 10, Plate 64, shows one of the two 10-inch × 10-inch automatic tension engines for operating the conveying ropes and the load carriage. One engine operates the inhaul rope, the other the outhaul rope. Both engines pull on their respec-

tive ropes, and therefore in opposition to each other. When the load carriage stands still at either terminal the automatic control compensates for the lengthening and shortening of the lines, due to the relative motion of the ships, and performs the functions of the main automatic tension engine.

When the load is to be hauled toward the warship the steam pressure is increased on the outhaul engine and decreased on the inhaul engine. This is done by moving a single lever. The operating gear of the engine is interconnected and controlled by this single lever. The lever pushed toward the warship causes the load to be hauled toward the warship. The lever pulled from the warship causes the carriage to reverse its direction. When the lever stands in a vertical position the carriage stands still. Thus the mind, the hand and the load move in the same direction. The art can be acquired with a few minutes' drill. Nothing can be simpler to learn.

The haul-down block and the load carriage are shown in Fig. 8, Plate 63. A load of bagged coal is being hooked on to the load carriage. This is accomplished in one or two seconds. Immediately after the load is hooked on, the haul-down block is slackened, the automatic tension engine takes in about 16 feet of suspended cable, and the load rises free of the deck of the collier. The operator of the two conveying engines pushes his lever toward the warship as soon as the bags are free from the deck. The haul-down block continues to rise, and the automatic tension engine continues to take up the main cable.

In Fig. 7, Plate 62, the carriage with its load of bags is seen crossing the bow of the battleship South Carolina. At this point the end of the main cable and its connecting bridle are rapidly lowered by winchmen to the deck of the warship. The carriage, continuing its travel, collides with the dump block, and the bags are automatically detached and fall to the platform. The cableway operator on the collier immediately pulls his operating lever, reversing the direction of the load carriage, which returns to the collier for another load. The sailors on the battleship then have one minute in which to take the bags from the platform and deliver them to trucks on deck.

Empty bags are returned to the collier in bundles every sixth or eighth trip.

SEA TRIALS—U. S. COLLIER CYCLOPS COALING THE U. S. S. SOUTH CAROLINA.

The official test of the marine cableway on the U. S. collier Cyclops used in coaling the U. S. S. South Carolina took place on April 12, 1913. The Trial Board was composed of Capt. Thomas Snowden, in command of the South Carolina; Naval Constructor L. B. McBride, of the Bureau of Construction and Repair; and Lieut. Halsey Powell, of the U. S. S. South Carolina.

The contract of the Navy Department called for a delivery of 480 tons of coal in a period of eight hours. The cableway was operated for six hours under most unfavorable conditions of sea and weather and was stopped because of darkness. After the trial was started a driving rainstorm developed and continued throughout

the afternoon of the test. The cableway was set up, and the automatic tension engines performed their functions for six consecutive hours and coal was transported for four hours.

DETAILS OF THE SEA TRIAL.

10.48 a.m.—Buoy was dropped from the collier.

10.50 a.m.—Buoy was picked up by the battleship.

11.00 a.m.—The two tow-lines were made fast.

Thus 12 minutes were required to pass and make fast the tow-lines.

11.05 a.m.—The main cable had been passed over and made fast.

This showed that it required only 5 minutes to set up the main cable.

11.09 a.m.—The tail block was made fast.

11.12 a.m.—All gear was made fast on the battleship.

This indicated that after the tow-lines were passed only 12 minutes are required to set up the entire apparatus.

11.19 a.m.—The marine cableway was entirely set up and ready to operate.

Thus only 19 minutes were required to set up the marine cableway after one ship had taken the other in tow.

Coaling was postponed until after dinner, was begun at 12.45 p.m. and continued until stopped by darkness.

During the trials no one was hurt, no bags were lost overboard, nothing was carried away, no damage was caused to anything, and no stops were made for adjustment excepting the block on the lowering device on the battleship.

A large part of the time the collier rolled 20 degrees.

During the last hour 83 tons of coal were delivered in 52 loads and in that hour, because of lack of organization on the battleship, the load carriage was held at the battleship end for the return of empty bags a total of 9½ minutes, clearly indicating that if the empty bags were returned promptly 60 loads would have been dropped in one hour. Many loads were dropped with only 50 seconds' interval.

When naval officers and seamen become familiar with the operation of the marine cableway, especially if they have had a few hours' drill, the capacity of the marine cableway will be materially increased. A great deal depends upon the efficient work at the warship terminal in taking away the loaded bags from the platform and the hooking on of the empty bags without delay to the traveling carriage.

Drill and practice of only a few hours on the collier, at the loading station, will also materially increase the capacity of the cableway.

Naval officers witnessing this test freely expressed the opinion that with drill and practice the cableway was equal to transporting 100 tons of coal per hour.

The cableway made 200 trips and delivered 312 tons, showing that the load averaged 3,495 pounds.

With the prompt return of empty bags the cableway will make 60 trips per hour. If each bag had carried an average of 50 pounds more coal, the result would have been 100 tons per hour. Sixty loads of 3,734 pounds each equals 100 tons per hour, which is clearly possible.

BAGGING AND TRANSPORTING COAL ON COLLIER.

Colliers of the Jason and Cyclops type, equipped with coaling-at-sea apparatus, should use their own clamshell buckets for digging coal in the hold and delivering it to a hopper located on deck. Coal from the hopper should be fed to coal bags on trucks. In this way one man will fill as many bags as nine men in the hold.

These trucks should run on tracks attached to the deck. An inclined portable section of track should be provided between the poop deck and the main deck for passing trucks from one deck to another. A winch and rope leading around the bags resting on the truck will safely transport the loaded truck up the incline. The truck may then be pushed by hand until it reaches the quarter-deck.

Here the track should make a circle around to the opposite side of the collier with two short side tracks, one on each side of the collier. Thus three trucks, each with two 800-pound bags, may be assembled abreast, when the six bags can be taken by the cableway carriage. At this point chocks will be necessary to hold the trucks until their load has been taken. The flanges of the wheels will keep the trucks in line, moving forward and aft, but the instant they reach a point directly at the loading station they will have to be controlled as against the rolling of the collier.

AUTOMATIC TENSION ENGINE VERSUS TOWING ENGINE AND SEA ANCHOR.

The author's first drawing of a cableway for coaling ships at sea, dated October 30, 1893, showed a "Compensating Tow-line Engine." None of the manufacturers of "towing engines" would undertake to build an engine or winch that would perform the functions required.

In a "towing engine" a considerable slackening of the tow-line causes the towing engine to operate its winding drum and thus coil in the slackened tow-line. The revolutions of the drum are geared to a steam valve and the pressure of the steam is thereby reduced. Subsequently an overstrain in the tow-line pulls the engine backward because it carried a low steam pressure. Again, the drum in unwinding through its connecting gear raises the steam pressure, thus leaving the towing engine in a position to act again to wind in the slackened cable. Towing engines are heavily compound geared. They are very slow in taking up the slack.

In the automatic tension engine, which had to be created for this special purpose, the instant the main cable slackens the steam pressure is immediately raised and the engine responds to restore the tension by winding in the main cable. Conversely, the instant the tension in the main cable is increased the steam pressure is immediately lowered and the engine yields and pays out as required. The automatic tension engine is capable of taking in slack even faster than it is given by the motion of a collier and a battleship operating in a heavy seaway. The automatic tension engine keeps practically a uniform tension in the line, while the towing engine makes no pretence of doing so.

The sea anchor, which formed an important part of all the earlier installations

of the marine cableway, was employed simply because the automatic tension engine had not been invented. The sea anchor, as a device for maintaining the tension in the main trackway cable of a cableway, was condemned by every U. S. Trial Board at every test employing it. It was adhered to by the author because its first cost was low and its weight and bulk very slight. It required too much skill and practice to launch it before coaling at sea and to recover it after the operation was over. It could only be used with colliers in tow of warships.

When the U. S. Navy Department refused to give the sea anchor any further consideration, the automatic tension engine was invented, designed and constructed to take its place.

The first main cable tension engine built, Fig. 12, Plate 66, was installed on the British collier Muriel. It contained a huge slipping drum. During the coaling operations the engine ran continuously, the drum floating backward and forward under the influence of the slipping friction. The heat developed and the wear of the slipping elements was terrific. The operation was successful but the machine impracticable for general adoption. The British Admiralty refused to adopt it. The author had nothing at the time to offer as a substitute. This machine, however, had the virtue of being a self-contained unit.

THE AUTOMATIC TENSION ENGINE—A NEW MARINE IMPLEMENT.

The automatic tension engine is a self-contained unit. It has two steam cylinders driving a common crank-shaft. A pinion on the crank-shaft drives a gear firmly keyed to the drum-shaft. The drum mounted on the drum-shaft is connected to it by huge coil springs, allowing a limited rotation of the drum on the shaft. Changes in tension in the rope cause the drum to rotate slightly on its shaft. This motion of the drum on its shaft is transmitted to controlling valves and raises and lowers the steam pressure as required.

This spring drum construction, therefore, is a feeler or detecter of tension changes. The steam for operating the engine is introduced into the cylinders through a novel form of controlling valve. This valve regulates the amount and pressure of the steam supplied to the cylinders. Suitable lever connections between the drum and this valve couple these two elements together in such a way that the steam supplied to the cylinders bears a definite relation to the tension in the rope.

Fig. 11, Plate 65, shows a cross-section of the spring drum of a small automatic tension engine, indicating the threaded hub and running nut together with the control lever and its connection to the pressure controller valve.

A slight increase in the tension of the cable produces a reduction of the steam pressure, permitting the rope to overhaul the engine and restore the tension to normal. A reduction of tension produces an increase of steam pressure, again causing the engine to act as a take-up to restore the tension to normal. The tension developed by this engine in pulling in is slightly less than the resistance set up in the cable to overhauling, but for all practical purposes the tension is uniform and constant.

Experiments at the testing station have been made in an endeavor to determine the interval of time between the slackening of the cable and the starting of the engine. No one has been able to measure the interval. To all intents and purposes it is instantaneous.

In addition to the automatic control of the tension fluctuations, the engine is provided with means for manually regulating the tension. The hand-wheel shown in Figs. 9 and 11, Plates 63 and 65, serves to control the amount of tension in the main cable. The top moved in one way increases the tension and in the other way decreases it. In practice, therefore, after the main cable has been secured to the battleship, the operator turns this wheel by degrees, gradually increasing the working tension of the main cable. An indicator on the engine shows what tension is being maintained at the time.

USES OF THE AUTOMATIC TENSION ENGINE.

Some of the military uses of the automatic tension engine are as follows:—

1. In connection with the marine cableway for coaling warships in a seaway.
2. Supporting an oil hose between two ships fuel bunkering at sea.
3. In connection with the marine breeches-buoy apparatus for life saving at sea.
4. Salvage work.
5. Landing guns ashore (see Fig. 17, Plate 68).
6. Sweeping for mines.

COALING AT SEA IN HALF A GALE OF WIND.

The author's paper before this Society in 1904 dealt with the marine cableway experiments by the British Admiralty (Fig. 13, Plate 66). Of these trials the London *Times* in March, 1902, said:—

"Capt. A. R. Wonham, who is in charge of the experiments, yesterday reported results to the Admiralty and further trials will now probably be ordered, the practicability of coaling at sea having been fully demonstrated. * * * During the experiments with the Empress of India there was a moderate sea and a wind of force five; and the result was regarded as highly satisfactory. * * * At a speed of about 10 knots the course was altered several times to test the strain on the cableway and then coaling began. During this operation the squadron of 17 ships in two lines passed on either side of the Trafalgar and Muriel to afford the officers an opportunity of witnessing the work and in a few days the experiment was repeated."

The British Admiralty was the first to invite a proposal for a trial marine cableway after the first marine cableway succeeded in coaling the U. S. S. Massachusetts at sea. The British Admiralty said they required a coaling-at-sea gear for a battleship. They wished to coal at sea from chartered colliers. The British Admiralty owns only one collier, the Mercedes, 9,900 tons.

The British Admiralty installed the first marine cableway upon the collier Muriel for experimental purposes.

The publicity given to this experiment started several English engineers upon the same problem. The Admiralty was overwhelmed with many coaling-at-sea inventions. The promoters promised greater capacity, lower first cost, less weight and less complication. One of the most promising of these was an apparatus invented by Engineer Commander Metcalfe. For several years the Admiralty experimented with various coaling-at-sea apparatus of Metcalfe's design. It is understood that these were manufactured in government dockyards. His apparatus was not adopted.

The Metcalfe apparatus comprised a continuously moving endless rope for supporting and transporting bags of coal from collier to warship. This endless rope was propelled by a winch. A movable pulley was introduced to form a bight in the endless rope which, in connection with a steam piston or ram, was intended to maintain a uniform tension in the endless rope and to act as a take-up and pay-out device to compensate for the motions of the ships. The play of the piston was necessarily limited. Should the ships approach one another the head of the piston might crash up against the head of the steam cylinder. And again, should the tow-line slip or part the piston might collide with the opposite end of the cylinder with disastrous results.

Up to the present time the only successful compensator introduced for the purpose of maintaining a uniform tension in the cableway or ropeway has been in the form of a winding apparatus.

The automatic tension engine, heretofore described, represents one such device, and the tensioning winch of Adam, which is an essential part of the apparatus adopted by Germany, is another.

A vast sum of money was expended in Germany by the backers of Engineer Leue, who had a corresponding apparatus with the piston compensator used in connection with a block and fall, but the friction of this block and fall introduced difficulties which made it impossible to maintain a uniform tension.

In a heavy sea, where the tension is not uniform, the lashing of the loaded strand of the endless rope in the Leue apparatus served to dislodge the bags in transit between collier and warship.

Even though a piston compensator would give an adequate amount of compensation, which, in the author's opinion, should be not less than 200 feet, nevertheless it is clear that any movable pulley in a bight of the endless rope could not have a travel of 200 feet on board any ship of war; or, at any rate, such a range of compensation would be impracticable.

A counterweight as a compensator failed utterly when tested on the U. S. collier Abaranda.

COALING A CRUISER AT A SPEED OF 12 KNOTS IN A SEAWAY.

Figure 14, Plate 67, shows the Italian cruiser Liguria towing the Italian collier Sterope at a speed of 12 knots in a sea rough enough for the screws of the cruiser

to be seen from the forecastle of the collier. The Liguria is a third-class cruiser of only 2,280 tons. The marine cableway for the collier Sterope was constructed in England by the Temperley Transporter Co. The sea trials of this equipment took place in the fall of 1906. The distance between the ships was 400 feet. This marine cableway was supplied under a guarantee to trans-ship 40 tons of coal per hour. In the trials 60 tons per hour were actually transported and the Trial Board reported that the demonstrated capacity of the machine was from 70 to 80 tons.

This experiment is of interest because in the United States there have been no attempts to coal light cruisers with the marine cableway. Furthermore, in none of the experiments in the United States has the towing speed been as high as 12 knots. It is also of interest to show that 60 tons per hour can be taken on board a light cruiser and disposed of.

The author will not attempt to describe the Sterope's equipment beyond saying that the operating machinery was too complicated for general adaption. It has since been greatly simplified, as indicated in the Cyclop's equipment.

No sea anchor was used in the trials, the entire equipment being carried on the collier.

OIL BUNKERING UNDER HEADWAY AT SEA.

The British Admiralty require a towing speed of at least 10 knots while refueling at sea. They coaled at sea in 1906 at a speed of 11 knots. The British Admiralty's tank steamer Petrolium trans-shipped oil at sea at towing speeds above 12 knots. The method they employ is practicable when the sea is smooth and is illustrated in Fig. 15, Plate 67. *Shipping Illustrated,* November 2, 1912, says:—"The operation of bunkering at sea while steaming at a rapid rate is regularly carried out by way of training. * * * Other nations have now adopted this method which is very effective but needs great care in seamanship and no little practice."

The British battleships tow the oil tank ship. One hawser tows and a secondary line supports the oil hose by hangers at frequent intervals. This plan was tested by United States ships with a small hose.

The tank steamer Petrolium carries 900 feet of 5-inch diameter flexible bronze hose, weighing 9 pounds to the lineal foot, a total of 8,100 pounds. The distance between ships is about 600 feet. The greater portion of the hose drags in loops in the sea. This results in great longitudinal strains, which damage the hose. The loops gather down against the bow of the towed ship, which affects the towing. They form many shary bends which shorten the life of the hose. Eighty tons of oil per hour are thus trans-shipped.

The United States Trial Board, testing this method between the fuel ship Arethusa and the destroyer Warrington, used a 2½-inch hose. They reported the difficulties substantially as mentioned above.

Figure 16, Plate 68, indicates diagrammatically an improved method for supporting the oil hose while trans-shipping oil at sea. The same-sized automatic tension engine and carrying cable used in the marine cableway are required for a proper support of the oil hose free of the sea.

An oil hose supported in this manner permits oil bunkering to be carried on in heavy seas. The automatic tension engine furnishes the necessary elastic medium for paying out and taking in the supporting cable as demanded by the motion of the ships. It maintains a uniform tension on the supporting line and prevents any lashing or whipping of the hose while the operation is being carried on in a heavy sea.

The weight of the 5-inch metal hose and the oil to be supported by the suspended cable is double the weight of the carriage and coal bags of the marine cableway. The necessary tension in the supporting line would be the same in both instances. The oil hose is a uniformly distributed load; the bags of coal a concentrated load frequently in the center of the span.

The automatic tension engine now installed on the collier Cyclops will develop a tension of 18,000 pounds and will sustain a 5-inch flexible bronze hose and a 1-inch diameter steel wire rope on a span of 600 feet with a deflection of about 58 feet. The rear mast of the Cyclops, with its heavy pulley block secured to the masthead for coaling at sea, is needed for oil bunkering at sea. The collier Cyclops carries both oil fuel and coal. Many of our battleships burn both kinds of fuel. The Cyclops can deliver either fuel if provided with a suitable oil hose, reel and oil pumps.

Oil bunkering at sea by such improved method can be carried on in a heavy sea, the time required for setting up and taking down the hose would be reduced, and all damaging strains in the line eliminated.

ASSUMING THE UNITED STATES AT WAR.

Rear-Admiral F. F. Fletcher, U. S. N., Commander-in-Chief of the Atlantic fleet, recently said to the Naval Committee in Congress, "In time of war the fleet should not be at any one port but should be out at sea and should stay there." Logically this is possible if supplied with coal at sea. Rear-Admiral Fletcher, when Aide for Material to the Secretary of the U. S. Navy Department, was largely instrumental in pushing forward the development of this, the latest form of marine cableway.

The United States at war with a first-class power during the next few years would be defended almost entirely by coal-burning ships, omitting destroyers and submarines, approximately as follows:—

13 first-line battleships, 10 burning coal,
23 second-line battleships, all burning coal,
10 armored cruisers, all burning coal,
5 first-class cruisers, all burning coal,
4 second-class cruisers, all burning coal,
15 third-class cruisers, all burning coal,

being a total of 67 coal-burning ships and three oil-burning ships.

Should our enemy send a fleet, including dreadnoughts, across the Atlantic, doubtless their first step would be to seize a base. This base might be the harbor of an island belonging to a neutral power. The United States fleet would probably attempt to bottle up the enemy with a superior force. The position of the United States fleet would then become similar to the British in the North Sea, except that there might be no suitable harbors for our dreadnoughts to be anchored and protected from submarine attack. We might not have a ship to spare and might need every ship to remain where it could strike when the enemy came out. This blockading fleet would need to be maintained at its highest possible efficiency.

The importance of maintaining the entire fleet on blockade duty, ready to fight the enemy the instant they came out from the harbor, is self-evident. This could be accomplished by assigning our big new colliers Jason, Orion, Neptune, Cyclops, Proteus, Nereus and Jupiter, fully equipped with marine cableways for delivering coal and oil to every ship at sea, when the sea and weather would not permit their coaling alongside. One of these colliers alongside the Wyoming, in a smooth sea, could give the Wyoming 1,000 tons of coal in 5 hours, using its clamshell buckets, while if the sea was moderate or not too rough it could give the Wyoming 600 tons in 10 hours with the marine cableway. This latter could be accomplished under the eye of the admiral while the Wyoming was steaming at a speed safe from submarine attack, holding her place constantly with the fleet.

The marine cableway now on the Cyclops has demonstrated to the satisfaction of a board of naval officers that it will deliver 600 tons in 10 hours, and it is the expressed opinion of eminent United States naval officers that under stress of war conditions 100 tons of coal per hour could easily be transported.

UNITED STATES SECOND-LINE BATTLESHIPS.

The twenty-three second-line battleships include the Massachusetts, Iowa, Indiana, and Oregon, which were on blockade before Santiago in 1898. On blockade these would have to be recoaled as often as they were in 1898. The bunker capacity of the Alabama, Illinois, Iowa, Indiana, Oregon and Arkansas is about equal to that of the Massachusetts, namely, 1,487 tons, and the necessity for recoaling these would be the same. These ships might burn 60 tons of coal per day, and prudence would indicate that they should be recoaled every 10 days.

UNITED STATES CRUISERS.

Our ten armored cruisers all burn coal. The bunker capacity of these cruisers ranges from 1,929 tons (Colorado) to 2,185 tons (South Dakota); displacement about 15,000 tons. These cost approximately $6,000,000 each. Patrolling on blockade, they would probably burn 60 tons of coal per day. These would doubtless coal every 10 days on an average.

Our five first-class cruisers, including the Brooklyn, all burn coal. Their dis-

placement is about 10,000 tons. The bunker capacity of these first-class cruisers range from 1,075 tons (Saratoga) to 1,776 tons (Charleston). These ships cost approximately $4,000,000 each. Patrolling on blockade, these ships would probably burn 50 tons per day and would probably coal every 10 days.

The four second-class cruisers all burn coal and range in displacement from 4,500 tons to 7,387 tons and have a bunker capacity of 850 tons (Chicago) to 1,525 tons (Columbia). The Olympia, one of these second-class cruisers, cost nearly $3,000,000. Patrolling on blockade, they would probably burn 45 tons per day and would probably coal every 10 days.

The fifteen third-class cruisers are all coal burners. They range from 2,212 tons displacement (Marblehead) to 4,687 tons (Chester, Salem, Birmingham). The bunker capacity for these ships varies very much, 428 tons (Boston) to 1,400 tons (Birmingham and Salem). These vessels cost about $2,000,000 each. At 10 knots' speed the Chester burns 40.44 tons per day, the Salem 53.85 tons per day, and the Birmingham 21.74 tons per day. These vessels, patrolling on blockade, would doubtless average 40 tons per day and would probably coal every 7 days.

The problem of maintaining the fifteen third-class cruisers continuously on blockade would not be a simple one. More than half of these carry approximately 700 tons. When consuming 40 tons per day they would be nearly empty in two weeks. Prudence would indicate that each should be coaled once a week. Two of these would therefore have to be coaled every day. This would be easily done from one collier of the Jason type should the sea be smooth enough to allow a cruiser to coal while steaming alongside the collier at a speed of from 10 to 12 knots. Coaling under headway is essential should submarines be present. When the sea would not permit of coaling broadside while steaming at sea, then recourse would be had to the marine cableway, in which the collier would tow the cruiser.

The Royal Italian third-class cruiser Liguria (only 2,280 tons) is smaller than any of the United States third-class cruisers. It received 60 tons of coal per hour from the marine cableway when towing the collier at a speed of 12 knots and in a sea in which the screws of the cruiser were seen from the deck of the collier in tow.

These small cruisers might be able to take on and stow coal 40 to 50 tons per hour and might consume the better part of a day to coal under headway in tow at sea.

It would be wholly possible to coal at night, for the Virginia was coaled by the marine cableway at sea in a dense fog when it was impossible for any part of either ship to be seen from the other.

Our small number of cruisers would seem to make it necessary to coal them at sea, to maintain them at anything like an efficient blockading fleet.

OUR FLEET CALLED TO BUENOS AIRES.

Rear-Admiral Bradley A. Fiske, U. S. N., in his prize essay before the United States Naval Institute, June 1, 1905, points out that:—

1. Our fleet should always be kept as full of coal as possible.

2. The only way to accomplish this is to have the colliers with the fleet continually in sight of the flagship.

3. A shore base insufficiently protected to withstand a probable enemy is an element of weakness rather than of strength.

With the above facts in mind imagine the Atlantic fleet sailing from New York to Buenos Aires, the United States being at war with a European power. The fleet would be accompanied by colliers. The fleet would probably steam at 10 knots to 12 knots. The shortest route is about 5,400 miles. This fleet should be kept as full of coal as possible, as Admiral Fiske indicates. If these vessels could fill their bunkers on the high seas without reducing their speed they will arrive with their bunkers practically full and in the shortest time and with the least consumption of fuel.

Battleships and cruisers of the Atlantic fleet can be coaled at sea without reducing the speed of the fleet below 12 knots. The proof for this resides in the results achieved with the marine cableway coaling the U. S. S. South Carolina (Capt. Thos. Snowden commanding) from the U. S. collier Cyclops at sea; coaling the U. S. S. Virginia (Capt. Jas. Glennon commanding) from the U. S. collier Vestal, Figs. 4 and 18, Plates 60 and 69; coaling the Italian cruiser Liguria at sea in Italy; coaling the Trafalgar and Empress of India at sea in England.

The trials of the South Carolina are representative of an average performance coaling in a seaway sufficiently rough to cause the collier Cyclops to roll 20 degrees.

In the Virginia trials the coaling operations were carried on for over an hour in a dense fog in which it was impossible for one ship to see the other.

In the Italian test the light cruiser Liguria of only 2,280 tons displacement was coaled at a towing speed of 12 knots when the screws of the cruiser were seen by the collier in tow.

In the English trials of the marine cableway, the towing speed was 11 knots, and the trials were carried on in half a gale of wind.

It would be difficult to exaggerate the importance of the passage of a fleet for over 5,000 miles without risk of violating the neutrality of any nation in coaling in their sheltered waters, nor in the delay or dangers incident thereto.

It is frequently asserted that there are numerous days when colliers and battleships could come alongside to coal. The equipment of these colliers with marine cableways would not prevent the ships coaling broadside whenever the sea and weather permit. The marine cableway insures coal to the fleet in all reasonable conditions of sea and weather.

Equipping such colliers as the Jason with marine cableways adds less than 3 per cent to their cost, and in the case of war would undoubtedly double their value.

The development of the marine cableway for coaling at sea has covered a period of twenty-one years and the device may be regarded as "being of age" in the year 1914. This apparatus, incorporated into the U. S. fleet for drill, practice, and use in maneuvers, will bring out its whole value.

DISCUSSION.

THE CHAIRMAN:—Gentlemen, you have heard the very interesting paper by Mr. Spencer Miller, and seen in detail the operation of the apparatus for coaling ships at sea. I trust we have present some gentlemen who have had practical experience with this apparatus and that they will give us their views on the subject and any additional information which may have come their way. I know that Mr. Miller has worked very hard over this matter. I have personal knowledge of his identification with this problem for over twenty years, and the success which has been attained is undoubtedly due to his earnest, intelligent and persistent effort. There must be some one here who has had experience on board ship with this apparatus. (A pause.) We have a written communication on this subject, which the Secretary will read.

CAPTAIN J. H. GLENNON, U. S. N. (Communicated):—The necessity for coaling at sea is brought home very strongly by the present war. It is, however, nothing new, as ships coaled with colliers alongside in the Spanish War off Santiago, and in such weather as prevailed could have coaled continuously. The Massachusetts once attempted to coal, head on to the port, and had to cast off her collier, as this was not a good heading. A day or two afterward she was absent from the battle off Santiago because she had gone to Guantanamo to coal. Relative to the Wyoming coaling in port at Guantanamo, there is no difficulty in coaling from two colliers in port, and it is probably the best way. But due to unsymmetrical loading and list of ship loaded, one collier may have eventually to regulate her speed to that of the other.

The constant tension engine will probably allow 100 tons per hour to be transferred from a collier to a warship, and it may be placed on another vessel. There is little difficulty in managing the operation, but the durability of the various appliances for successive coalings has not, so far as I know, been determined.

CAPTAIN A. P. NIBLACK, U. S. N., *Member of Council* (Communicated):—In these days of the discussion of naval preparedness and efficiency, it is pleasant to be able to state that in matters of supply of the fleet in its relation to sea keeping, the United States Navy stands pre-eminent and in a class all by itself, there being no second. Our repair ships are a marvel of up-to-date efficiency. Our cold storage and fresh provision supply ships are a constant wonder to foreigners. Our battleships all carry forty days' cold storage for the entire crew, and five months' dry provisions. In no other navy is more than a few days' fresh provisions carried. In sea keeping, in radius of action of our ships as to fuel supply carried on board, in competition as to the efficient utilization of stores, and in the thought given to operating at long distances from base, our results are very gratifying.

Also our Navy alone goes in for special naval colliers (coal and oil), and we alone of all navies have thirteen large modern ones, not to mention eleven older and smaller ones. None, however, of the newer ones are as efficient as they should be, simply for the lack of vigorous initiative in bringing them completely up to date, and finishing their equipment. Having paid about one million dollars apiece for them, there is now needed about $25,000 apiece to finish them.

All should have spare hammock hooks, cooking facilities, and equipment for extra men for transport. All should have gun emplacements. All should have oil pumps, and working facilities for carrying fuel oil. Most of them should have the best and latest arrange-

ments and types of gear for side coaling. All should be fitted, as Mr. Spencer Miller here points out, with the cableway and coaling-at-sea apparatus.

Each collier should be taken in hand, and brought up to date. We have done splendidly, but we have stopped short of thorough efficiency.

THE CHAIRMAN:—Certainly the reluctance of members in coming forward to discuss this paper, and the absence of criticism is, in one sense at least, very gratifying to Mr. Miller, I am sure. He remarked in presenting his paper that the keystone of the arch was the tension engine. I think any one, after his explanation—and certainly those who have had practical experiences—realizes that it is the very foundation of the success of the performance of this apparatus. The successful fueling of ships at sea is to-day much more important than it was when Mr. Miller began his experiments. We have now come to appreciate the vital importance of this matter.

I do not care to express too advanced opinions one way or the other, but I think it can be accepted as self-evident that if you have an effective arrangement for quickly fueling ships at sea while under way at very fair speed, you have provided the best means of fueling promptly and in security under blockade conditions; and this, of course, is most important under modern conditions of naval warfare. Having had some personal experience with Mr. Miller's work during the development of this apparatus, I feel that I can safely congratulate him upon the success attained up to the present time, and that success, as I said before, is based largely upon the efficiency of the tension engine. The Chair did not expect to be called upon to make any remarks, and he would still be glad to hear comments from any members present. (Applause.)

Your task, apparently, is a very easy one, Mr. Miller, so far as responding to any adverse criticisms made on the apparatus is concerned. If you desire to give us some further information, I am sure we will be very glad to hear it, as it is a most interesting subject and, as you see, has been received by the audience with a great deal of appreciation.

MR. MILLER:—The author extends sincere thanks to Admiral W. L. Capps, U. S. N., for his kind congratulations. Admiral Capps, as Chief Constructor of the Navy Department, invariably stood on the side of progress in the development of apparatus to meet the demands of the fleet for coaling in a seaway. His assistance was always encouraging and most important in the perfection of the marine cableway.

Captain J. H. Glennon, U. S. N., discussed the paper from the storehouse of his great experience. He was an officer on the Massachusetts that abandoned its place off Santiago because unable to coal at sea. He commanded the Wyoming when it was coaled by the colliers Nereus and Proteus, referred to in this paper. He commanded the Virginia when it carried out the official tests of the marine cableway, and to him the author owes a debt of gratitude for the masterly way in which the apparatus was handled during these sea tests. With but an hour's previous drill the men under his command transported 72 tons of coal in the first hour and 69 tons of coal in the last hour of the test carried on in a heavy fog. It is a pleasure to note that, after this experience, Captain Glennon should write that the marine cableway with its automatic tension engine can transport 100 tons per hour.

Captain A. P. Niblack, U. S. N., is another line officer always demanding greater coaling efficiency. His written discussion adds value in that it indicates clearly a need for further equipment to our splendid colliers to make them far more valuable than at present.

Vice-Admiral Sir S. M. Eardley-Wilmot, R. N., who had much practical experience on blockade duty, acknowledging receipt of the paper, replies as follows:—

"There is no doubt that the ability to replenish bunkers with coal or oil at sea in almost any weather is of the utmost importance."

Referring to means for coaling bow and stern at sea, he adds:—

"That of course is the only reliable method, for the open sea is seldom calm enough to allow two large vessels to lie alongside each other without great risk. To take a vessel in tow under way requires skilful seamanship but is, I believe, practised in most navies. Your automatic tension engine seems to have successfully overcome one of, if not the principal, difficulties in the towing operation, and hence I think it should obtain universal adoption."

Sir Eardley-Wilmot suggests that oil could be transported in tanks of one-ton capacity by the marine cableway as being simpler than using a heavy hose. This suggestion, coming as it does from a vice-admiral in the Royal Navy, indicates that the use of an oil hose for oil bunkering at sea presents many difficulties.

Sir Eardley-Wilmot's suggestion to transport the oil, using the marine cableway and employing tanks instead of coal bags, is entirely practicable. Attention is directed, however, to the necessity for reducing the time of loading the cableway at the oil ship and unloading the tank at the warship to an absolute minimum. The cableway should deliver a load every 60 seconds. Thirty-five to 40 seconds will be consumed in transporting the carriage back and forth on the cableway. The loaded tank should be hooked on at the oil ship in 10 to 15 seconds and emptied at the warship in 10 seconds, making a total of 60 seconds.

Apparently the quickest way of emptying the tank would be to turn it upside down. With an oil tank properly suspended this would seem feasible. A huge funnel, temporarily erected above the warship deck, would serve to receive the oil without loss and convey it through a hose to the bunkers.

At the loading end on the oil ship, where the cableway carriage stops, a special shunting truck or platform could be mounted on a short section of track athwartship. This truck should have two padded pockets to carry the tanks. One tank would be instantly detached and dropped to its pocket on the special truck. A quick push on the truck athwartship would bring the loaded tank directly under the carriage. The tank bale would then be hooked on the carriage, the haul-down slackened, and the tank would be started on its way to the battleship.

With such a loading arrangement it would be possible to reduce the delay at the loading engine to a matter of 10 or 12 seconds, and 60 trips per hour would therefore be possible.

The cableway has a carrying capacity of 4,000 pounds. An oil tank, to carry 1¼ tons of oil (2,800 pounds), would weigh 1,000 pounds. The total load on the carriage would therefore be 3,800 pounds. With 60 trips per hour this would result in a capacity of 75 tons an hour.

Rear-Admiral Reginald G. A. Tupper, R.N., a naval officer with extended sea experience, being a rear-admiral in the Home Fleet 1912–1913, in acknowledging receipt of a copy of the paper, and noting that the author credited him with the first suggestion for continuous rope apparatus, adds:—

"As a matter of fact the date of my paper to the Admiralty on the subject was considerably earlier than that of Lieutenant Bell's, but I was before my time and got but little credit and was told it was considered impracticable, and although I later on suggested improvements I got no encouragement and so did not go on with it."

Rear-Admiral Tupper says that the automatic tension engine would be of great value in sweeping for mines, and in this he speaks from personal experience. Nothing could be better than an automatic tension engine for this purpose. It would be superior to a towing engine because it maintains a practically constant pull in the mine-sweeping cable yielding to every over-pull. In fact two over-pulls could occur in succession without overstraining the cable itself. With the towing engine the slack take-up and overstrain pay-out must succeed each other like the swing of a pendulum. The automatic tension engine will take up slack several times in succession and pay out over-pulls several times in succession.

The author is greatly indebted to the membership of the Society for their cordial reception of this paper and to all those in official life in Washington and at sea, who have done so much to advance the development of the marine cableway.

THE CHAIRMAN:—The meeting has already evinced its appreciation, Mr. Miller, and I desire to extend to you the hearty thanks of the Society for presenting your paper.

Like a good housewife, the Council of the Society has apparently reserved some of the best of our intellectual feast for the closing hours, and we will now have a paper which undoubtedly will give you much pleasure. It is No. 14, the last paper to be presented at this meeting, and is entitled, "The Applicability of Electrical Propulsion to Battleships, together with the Experience Gained with it on the Jupiter," by Lieutenant S. M. Robinson, U. S. Navy. We regret that Lieutenant Robinson is not with us. He is apparently detained on duty. Naval Constructor Linnard has consented to read the paper in the absence of Mr. Robinson.

Naval Constructor Linnard read the paper.

THE APPLICABILITY OF ELECTRICAL PROPULSION TO BATTLESHIPS, TOGETHER WITH THE EXPERIENCE GAINED WITH IT ON THE JUPITER.

By Lieutenant S. M. Robinson, U. S. N., Member.

[Read at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers, held in New York, December 10 and 11, 1914.]

There are at present so many different methods of ship propulsion that it is impossible to make any general statement as to which method is the best. Questions of horse-power, speed, size of vessel, duty it has to perform, etc., all have so much bearing on the subject that each class of vessel has to be considered separately. For this reason this paper has been limited to a discussion of battleship propulsion.

A great number of schemes for the propulsion of battleships have been tried and a still greater number have been proposed, but it is not believed that any of them have such ideal qualities for this purpose as electric propulsion.

Before taking up the applicability of electric propulsion to battleships, a description will be given of the probable arrangement that would be used. Briefly, it would consist of two high-speed turbo-generators and four induction motors. The motors would be arranged with one motor on each of four shafts. There would be a switchboard (or rather a board for mounting instruments) in each engine-room, but under all ordinary conditions of steaming, all operating would be done from one switchboard and only one turbo-generator would be used. Only at very high speeds would both generators be used, and in that case the two engine-rooms would be operated independently. The switchboards would be so arranged that either generator could run all four motors from either switchboard; also so that any motor could be cut out at any time, allowing the ship to be run with three motors. All these switches would be of the simple knife-blade type, enclosed in waterproof boxes so arranged that they could not be moved when the circuits were alive. For connecting each pair of motors for ahead or astern motion, oil switches would be used which would be capable of breaking the heaviest current which could pass. In actual operation, however, the field circuit of the generator would always be open before moving these switches, so that the oil switch would really break very little current.

No attempt will be made to give a detailed description of the turbines, generators, and switches that would be used for a battleship, as the number of possible arrangements is too great. However, the equipment would be similar in most essentials to that in use on the Jupiter, and that will be described later on when that installation is taken up. The principal difference between the two equipments

would be in the motors used. Since the Jupiter's installation was made, a new type of induction motor has been developed which makes it possible to do away with the water-cooled resistances used on the Jupiter; this simplifies the wiring somewhat, and also simplifies the operation, as it eliminates the use of the short-circuiting levers for throwing in and out the water-cooled resistances.

This motor is a double squirrel-cage motor; it has two independent squirrel cages on the rotor, the outer one having conductors of high resistance and the inner one conductors of low resistance. At high frequencies, such as would obtain in the rotor when starting up or backing, the inner winding takes practically no current, due to its high reactance under these conditions; therefore the high resistance winding on the outside is the only one in operation and this insures large torque for starting or backing. The torque for backing conditions would also be improved by automatically establishing maximum excitation before backing. The connections for reversing would be so arranged that maximum excitation would be established automatically during the act of reversal, no matter what the excitation may have been before reversal. When the motor is running close to synchronous speed, the reactance of the inner conductors is very much reduced, and they then operate like any ordinary squirrel-cage motor. At intermediate speeds between synchronous speed and standstill or back, both the inner and outer conductors would take some current, and the torque characteristic curve would be the resultant of the two windings.

The motors for a battleship would differ in one other particular from those used on the Jupiter. The stators would be provided with pole-changing switches so that there would be two speed reductions between generators and motors. This would enable the generators to be run at full speed both at the full speed of the ship and also at some intermediate speed nearer the cruising speed of the ship. The normal cruising condition of the ship would be to have one generator running and to have the pole-changing switches on the motors thrown so as to give them the larger number of poles and consequently the greater speed reduction. This combination would be used till the speed limit of the turbine is reached; this point would probably be about 15 knots in a 21-knot ship. From this point on to about 19 knots, one generator would be used driving four motors with the pole-changing switches thrown to give them the smaller number of poles. For speeds above this both generators would be used, each driving two motors with pole-changing switches thrown to give them the smaller number of poles.

In choosing a method of propulsion for battleships, there are six points to be considered. They are, in order of their importance:—

1. Reliability.
2. Maneuvering qualities.
3. Economy.
4. Space occupied.
5. Weight.
6. Care and upkeep.

Reliability.—Taking these points in their order, the first to be considered would be reliability. The reliability of induction motors and large high-speed turbo-generators for land use has been well known for some time, but up to about one and one-half years ago had not been demonstrated on board ship. However, experience at sea with them has not developed any trouble, and their reliability is now unquestioned. There are several things that go to make an electric installation more reliable than any other. First, the installation is in duplicate throughout and the breaking down of one engine does not affect the ship except at high speed; it might be said that this is true of other installations, but it is not true in the same sense nor in the same degree that it is with the electric drive. For example, if one turbo-generator breaks down, the ship can still run in a perfectly normal manner up to a speed of about 19 knots. This would be impossible with any other mode of propulsion; even at speeds within the power of one engine on a twin-screw ship the maneuvering qualities would become so bad as to handicap the ship; in fact a twin-screw ship operating with one engine would be able to reach port safely but would be of very little use in battle, whereas an electrically-driven ship, operating with one turbine, would be just as good as any ship up to a speed of about 19 knots.

Then, too, there is the question of auxiliaries; with other forms of propulsion, if the auxiliaries in one engine-room break down, that engine-room may be almost entirely put out of commission. Of course the main air and circulating pumps are cross-connected, but when operating that way they are not very satisfactory and I have seen a battleship forced to stop because the forced lubrication pumps in the starboard engine-room broke down. If the ship had gone ahead with the port turbines, the starboard turbines would have revolved and burned out the bearings, so that it was necessary to stop the ship and repair pumps; with the electric drive it would be a simple matter to shift to the other engine-room and make repairs without stopping.

There is one other thing that makes this installation more reliable than other forms of turbine-drive, and that is the fact that the turbine revolves in the same direction all the time. The importance of this cannot be overestimated, as it is believed by operating engineers that the greater amount of blading trouble that ships have had is nearly always due to the distorsion that occurs when backing. There is also one other advantage when compared with reciprocating engines, and that is that the turbines would be much less susceptible to damage by water when the boilers are priming. This fact has been thoroughly demonstrated by experience on the Jupiter.

Maneuvering.—As regards maneuvering qualities, it is believed that the electric drive is far superior to any other method. This point will be taken up more in detail when the Jupiter's installation is discussed. It is rather difficult to describe these advantages on paper, but very easy to appreciate them when you see the machinery working. Instead of big, heavy throttles to open and close, there are light, easily handled oil switches, and a speed controller that can be handled with one

finger. The engine-room watch required for a battleship would be just half what it would be with other means of propulsion, as one engine-room would be idle practically all the time. In a rough sea there is no racing, with its attendant strains on machinery and on the personnel on watch. Any desired speed can be very quickly attained. The speed can be very accurately maintained and without any effort on the part of the personnel. These last two points are of very great importance on battleships when maneuvering in formation. The stand-by qualities are also superior to those of other installations, for at a very small expense in the way of steam, the main turbine can be kept running very slowly and the engine-room is then ready to answer signals at any time; this might be of great importance to a battleship. The backing qualities of this installation are also superior to other forms, particularly turbine installations. It is possible to attain full power in the astern direction.

Economy.—In considering the question of economy, we have reached the point which first suggested the use of electricity for the purpose of propulsion. None of the older forms of propulsion, such as reciprocating engines or direct-connected turbines, can compare at all favorably with this method, the gain in economy being over 20 per cent both at high and cruising speeds. The only other method of propulsion that would appear to compete with this method in economy would seem to be the combination of high-speed turbines and reduction gears. The loss in the latter amount to about 2 per cent, while in the electric reduction gear the losses are from 8 to 9 per cent. Mechanical reduction gears have been developed to a high degree, and it is very probable that in quite a number of cases the mechanical gears would be preferable to the electric drive, but as this paper is limited to a discussion of battleships that subject will not be touched.

For battleships I do not believe there is any question of the relative economy of the two methods—the electric drive is far superior. The electric reduction method possesses two inherent advantages that the mechanical method cannot overcome. First, the electric installation uses only one turbine at low powers; second, the induction motors are fitted with pole changers which allow the turbine to be run at normal speed with the ship cruising at low speed—in other words, the electric drive permits of two speed reductions while the mechanical gear has only one. These two advantages exist no matter how the two installations may be laid out, and they far outweigh the difference in the losses of the two methods. To show just how great these advantages are, two curves are shown. Plate 70 shows the Jupiter's turbine operating under varying loads and Plate 71 shows the turbine operating under varying speeds (and also loads). The load curve does not really show how very bad the conditions are for a battleship, as in that case the power at 12 knots is only about one-seventh what it is at 21 knots and the curve shown does not give so great a per cent of reduction. It will also be seen that the speed curve is very steep at the low speeds and shows the bad effect of reducing turbine speed very greatly. As nearly all the cruising of a battleship is done at fairly low speeds, it is evident that the electric drive will be more economical than the mechanical gear.

In addition to the two advantages just stated, there are a number of other things entering into a comparison of the two methods that make it very doubtful if the mechanical gear would be as good, even at the high speeds, as the electric reduction. It would probably be necessary to use at least four turbines with a mechanical gear instead of two with the electric method; this fact alone would make the electric reduction the more efficient of the two. Then there are also the very considerable losses due to the friction and windage of the backing turbine. According to Sir Charles Parsons this loss amounts to about one-half a per cent. Also there would be a saving due to the fact that only one set of auxiliaries would be used at a time.

Space Occupied.—As regards the actual space that the machinery would occupy, the electric drive would take up less space than any other installation, with the possible exception of the mechanical gear. The arrangement of the machinery, however, is so much more flexible with the electric drive than with other methods that it is probable it would occupy less space than would the gears. It lends itself very readily to watertight subdivision.

Weight.—The next point to be considered is that of weight, and here again the electric drive is superior to any other method, with the possible exception of mechanical gears. It is rather difficult to say exactly how the two methods would compare either as regards space or weight, as a great deal would depend on the number of turbines used with the mechanical gear in order to get 30,000 shaft horsepower. However, if the largest sizes of geared turbines now at sea are any guide, the weight of the electric drive would be less than the weight of the geared turbine.

Care and Upkeep.—As regards care and upkeep, the electric drive is greatly superior to either reciprocating engines or direct-connected turbines; also, due to the fact that the turbines do not have to reverse, it would be superior to the geared drive in that it would have less blading trouble. Either of the two latter methods, however, is very satisfactory in this respect, as a high-speed turbine is so small that it is easily handled and repaired by the ship's mechanics.

This completes the case of the electric drive for battleships; all of the points have been considered and in every case it has been seen that it has no superior. There are, however, some points that have been made against electric propulsion, and these will be taken up before proceeding to a discussion of the Jupiter's installation. First, there is the danger from large quantities of water in the engine-room; however, this danger is more fancied than real, as all the wiring could be placed well overhead, being taken out of the tops of the motors and generators. The generators could be placed high enough to insure their safety and the motors could be placed in watertight pits so that the engine-room could have enough water in it to put the auxiliaries out of commission before reaching the main engines. The next point is that, when operating with one turbine, all motors must run at the same speed if they run at all; this fact has been found to be no handicap in actual operation. The next point is that, in turning, the inboard screw does not slow down;

this slightly increases the turning circle, but does not increase the space necessary to turn in, as the inboard screw can always be stopped or backed.

Before taking up the work of the Jupiter's engines, a brief description will be given of the ship and her propelling machinery. The Jupiter is of the twin-screw, single-deck type. She was designed for a speed of 14 knots, developing 5,500 shaft horse-power, with a load displacement of 19,300 tons, at a draught of 27 feet 8½ inches. The general dimensions of the ship are as follows:—

Length over all	542 ft. 2½ ins.
Beam, extreme	65 ft. 3 ins.
Draught, mean designed	27 ft. 8½ ins.
Coefficient of fineness, block	.7215

There are three double-ended, return-tubular, marine type Scotch boilers, and one upright donkey boiler. The main boilers have the following dimensions:—

Length over all	23 ft. ¾ in.
Diameter	16 ft. 3 ins.
Diameter of furnace (inside)	3 ft. 4 ins.
Number of furnaces, per boiler	8
Length of grates	5 ft. 7½ ins.
Grate surface per boiler	150 sq. ft.
Heating surface per boiler	6,460 sq. ft.

These boilers are designed for a working pressure of 190 pounds per square inch, but safety valves were set for 200 pounds per square inch for the preliminary trial. Howden's forced draught system is used. The incoming air to the blowers, which are of the Sturtevant type, passes through the motors and generator, thus giving a certain amount of preheating to the air which is used for combustion.

There are two solid, manganese-bronze propellers. They have a taper fit on the tail shaft, and they are keyed and held in place by a bronze nut. They have the following dimensions:—

Diameter	15 ft. $11\frac{7}{16}$ ins.
Pitch	14 ft. $5\frac{1}{16}$ ins.
Expanded area	70.5 sq. ft.
Projected area	60.53 sq. ft.
Disc area	198.97 sq. ft.
Weight, one propeller	13,900 lbs.

These propellers were designed by Captain C. W. Dyson, U. S. Navy, and show a remarkable efficiency, giving the same speed as her sister ships on from 300 to 800 less horse-power.

The main propelling machinery consists of a nine-stage Curtis turbine, a two-pole, three-phase AC generator, two 36-pole, three-phase induction motors, two water-cooled rheostats, and one main switchboard. The following general dimensions are given:—

Turbo-Generator.

Weight of bed plate	16.3 tons
Length of bed plate	25 ft. 2⅛ ins.
Length over all	27 ft. 7¼ ins.
Height, extreme	9 ft. 5¼ ins.

Turbine.

Weight	28.7 tons
R. P. M., normal	1,990
Number of stages	9
Number of rows of moving blades (two rows in first stage)	10
Number of rows of fixed blades (first stage)	1
Minimum clearance	.06 ins.
Maximum clearance	.18 ins.

Generator.

Weight	35.7 tons
Number of poles	2
Normal volts	2,300
Normal amperes	1,370
Normal frequency	33.2
Normal excitation	250 amperes
Normal R. P. M.	1990
Rated capacity	5,450 kw.
Rotor core length	60 ins.
Air gap	$1\frac{3}{16}$ ins.

Motors.

Number	2
Weight (two)	76.8 tons
Type, induction (definite wound rotor)	"M"
Number of poles	36
Rated capacity	2,750 horse-power
Normal R. P. M.	110
Air gap	.1 in.

The excitation for the main generator is taken from one of the ship's 35-kw. generators.

The turbo-generator furnishes power to the motors, the function of the generator and motors being solely that of a reduction gear. All changes of speed are made by changing the speed of the turbine, thus varying the frequency of the generator, and consequently the speed of the motors, the reduction in this case being eighteen to one, plus the slip of the motors. The motors are wound for only one number of poles and therefore the speed ratio is not changeable as it would be for a battleship installation; the reason for this is that such change is not necessary as the cruising speed is practically the maximum speed.

Speed changes are accomplished by means of a small control stand in front of the switchboard. A small hand-wheel on this stand, working through a worm, worm wheel, and set of bell crank levers, changes the position of the fulcrum about which the governor acts, thereby varying the speed of the turbine.

One of the three-phase windings from the generator is led to the two motors direct. The other two leads are taken to the main switchboard, then through "ahead" or "astern" oil switches, and then to the motors.

Each motor is installed in a watertight pit which cannot easily be filled with water from below. However, the motor windings are all made waterproof and fireproof, and are intended to give safe running when partially submerged. The rotor windings are connected to collector rings, which are in turn connected to the water-cooled rheostats. These collector rings can be short-circuited by a slider, operated by a lever and working on the motor shaft. The short-circuiting device consists of a brass segment under each ring and a corresponding segment on the slider. In addition to these devices there is an auxiliary device working with each main device. The auxiliary consists of a carbon block on the solid segment and a brass contact on the slider; these contacts are held in place by flat springs on their back and will thus be forced into contact before the main contacts are, and will leave the carbon blocks after the main contacts have let go. The purpose of these auxiliary contacts is to prevent the main contacts from being burned when operating the short-circuiting lever. These short-circuiting levers are locked, when in the "resistance out" position, by electric solenoids in series with the field of the main generator; this prevents this lever from being moved out of this position while the circuit is alive. It was found in the factory that excessive burning took place when it was attempted to short-circuit the collector rings with full field on, and the lock was put in to prevent this.

There are two water-cooled rheostats, one for each motor, the total weight of both being 5.8 tons. Each one consists of a top header, bottom header, three larger porcelain cylinders at the bottom, three small porcelain cylinders on top of these, and one noninductive resistance inside each of the large porcelain cylinders. These resistances are made of calorite, and consist of spiral coils laid up on a wooden spindle and having alternate coils connected oppositely from the others so as to make the resistances noninductive. The large porcelain cylinders rest on rubber gaskets on the bottom header, the resistances sit inside these cylinders, a rubber gasket and a brass ring go on top of each large cylinder, and the small cylinders

are placed on these gaskets. The top header rests on gaskets on the tops of the small cylinders. The rheostats are supplied by water either from the main circulating pumps or the flushing pump. These rheostats are capable of running under full load for an indefinite length of time.

The main switchboard is supplied with a voltmeter, ammeter and indicating wattmeter for the main generator, with a voltmeter and ammeter for the field of the generator, with a frequency and speed indicator for main generator, with ammeter and recording wattmeter for the motors, with "ahead" and "astern" oil switches for the motors, with a field switch for the main generator, and with a rheostat and switch for the field of the exciter. The control stand is in front of the center of the switchboard. The "ahead" and "astern" oil switches have mechanical interlocks so that the "ahead" and "astern" switches for a motor cannot both be thrown in at the same time. There is also a mechanical interlock from the short-circuiting levers to the oil switches, which prevents the oil switches from being thrown in when the rheostats on the motors are short-circuited by the levers.

The operation of the machinery may be divided into three different conditions. Starting with all auxiliaries in operation, the turbine running, and an exciter cut in on the field of the generator, the operation under different conditions would be as follows:—

1. Getting under way, coming to anchor, going alongside a ship, or, in general, handling the ship where much reversing might be expected.

Under these circumstances the resistances would be kept in on both motors. The operation in this condition is very simple. To go ahead or astern on either motor, simply close the "ahead" or "astern" switch; this requires about one-half second for each motor.

2. When it is desired to do economical cruising.

This condition will arise after a certain amount of shiphandling has been done, and both resistances will of course be in on the two motors; it will be necessary to cut the resistances out of the motors. This operation is not performed in answer to a signal from the bridge, but is merely a change of cruising conditions. To carry out this change, first open the field switch of the exciter; second, move the control wheel of the turbine to "slow speed;" third, move both short-circuiting levers so as to short-circuit the rheostats; fourth, close the exciter field switch; fifth, bring the turbine up to the desired speed. The total time required for these operations is about thirty-five seconds; about twenty of these seconds are used up in waiting for the field circuit of the generator to die out sufficiently to allow the short-circuiting levers to be moved. As has been previously stated, the short-circuiting levers are locked by solenoids in series with the field of the generator. When the exciter field switch is open the main field will, of course, die down and allow the short-circuiting levers to be moved.

3. When doing economical cruising, with resistances out of both motors, a signal is received to back either one or both motors.

First, open the "ahead" oil switches; second, move the short-circuiting levers

so as to put in the resistances; third, close the "astern" or "ahead" switches as desired. The total time required for these operations is about three seconds. When the installation was first designed, the solenoid locks in the generator field circuit were so arranged as to prevent the short-circuiting levers being moved either to cut out or cut in the resistances, but it was found that, with the motors dead (that is, with no oil switches closed), the short-circuiting levers could be moved with impunity, so that notches in the lock were filed to allow the short-circuiting levers to be moved to the "resistance in" position without changing the field of the generator. This was a great improvement as it made it possible to give practically instantaneous backing at all times and under all conditions.

In connection with the operation of machinery there are several other conditions that might possibly arise in addition to the normal condition given. The rheostats might become disabled, in which case the mechanical interlock between short-circuiting levers and the oil switches would be disconnected, making it possible to move the oil switches with the rheostats cut out. The ship could then be maneuvered satisfactorily, but it would always be necessary to slow the ship down before backing the motors. This condition has been tried out experimentally, and it was found that up to speeds of about 9 knots the operation was just as satisfactory for starting up and backing with the resistances out as it was with them in. Above that speed it was necessary to wait until the ship slowed down.

If either motor were disabled, the ship could, of course, be propelled with the other.

In case of failure of the governor, the speed could readily be controlled by the throttle itself.

In case of damage to one or more stages of the turbine, the blading of these stages could be entirely removed or simply opened up enough to allow the passage of steam through them, and the turbine operated.

The General Electric Company, in its contract with the government, guaranteed a water-rate of 15 pounds of water per shaft horse-power hour delivered to the propeller shafts at ten knots, and a water-rate of 13 pounds of water per shaft horse-power hour delivered to the propeller shafts at the highest speeds attainable. The government guaranteed to furnish steam to the turbine at 190 pounds (gauge), or to allow an increase of one per cent per specified horse-power for each 10 pounds of reduction in steam pressure. It also guaranteed to furnish 28.5 inches of vacuum or to allow an increase in the water-rate of 5.0 per cent per specified horse-power per inch of reduction in vacuum. The results of the preliminary trial are given in the following table:—

TRIAL DATA.

	48 hours	*24 hours*
Date of trial	Feb. 14–'14	Feb. 18–'14
Speed, in knots	14.99	10.01
Draught, mean	27 ft. 9 ins.	27 ft. 7½ ins.
Displacement, in tons	19,452	19,350
Pressures (gauge):—		
Main steam, boilers, pounds	193.8	193.9
Engine-room, pounds	185.8	186.44
Turbine, pounds	168.4	180.56
First stage, pounds	56	8.5
Forced lubrication, pounds	30	30
Oil to governor relay, pounds	80	75
Steam seals, pounds	5	5
Auxiliary exhaust (absolute)	23.19	23.68
Air pressure to boilers, in inches of water	.712	
Vacuum, inches	28.2	28.5
Revolutions or double strokes per minute:—		
Starboard motor	116.72	77.077
Port motor	116.72	77.077
Main turbine	2,130	1,410
Wet air pumps	3,600	3,600
Dry air pumps	112	113
Circulating pumps	193	196
Feed pumps	22	17
Blowers	329	
Temperature, in degrees Fahrenheit:—		
Main injection	55	55
Overboard discharge	78	72
Hottest bearing (middle)	133	115
Oil from cooler	99	85
Feed water	191.9	215.9
Field amperes, main generator	251.5	184
Volts, main generator	101.4	69.44
Volts, main generator	2,580.6	1,524
Amperes, starboard motor	725	395
Port motor	755	413
Main generator	1,480	808
Kw., starboard motor	2,692.7	712.5
Port motor	2,833.1	751.3
Total kw.	5,525.8	1,463.8
S. H. P., starboard shaft (torsion meter)	3,603.258	1,053.959
Port shaft (torsion meter)	3,548.677	961.08
Total (torsion meter)	7,151.9	2,015.04

Water consumption data:—		
Total pounds per hour	105,764	40,066
Pounds per hour auxiliaries	22,212	15,246
Turbine	83,552	24,820
S. H. P. (turbine)	11.68	12.316
Guaranteed water-rate, pounds	13	15
Fuel consumption data:—		
Pounds of coal per hour	11,900	5,050
Pounds per hour per S. H. P.	1.662	2.5056
Pounds per sq. foot heating surface	.613	.261
Tons per day	127.39	54.082
Kind of coal	New River & George's Creek.	
Quality of coal	Run of mine.	Run of mine.
Slip of propellers, per cent	9.9	8.74
S. H. P. per square foot of grate surface	15.9	4.48
Knots per ton of coal	2.82	4.43

The Jupiter has been in commission over a year and a half. During that time she has conducted two official trials and has carried on the usual routine work of a navy collier. She has steamed about 14,000 miles and has been handled a great deal around docks, in narrow channels, and other places where a great deal of engine handling was required. About one-half of the steaming has been done in the tropics with circulating water over 80° F. and with correspondingly poor vacuum, so that the economy of the ship is known under all conditions. The fuel economy has proved to be excellent, being, on the average, about 25 per cent better than the best of her sister colliers.

During the whole period of commission, two repairs have been made to the main engine. The first was to reblade the first stage of the turbine. This work was done entirely by the ship's mechanics. The first stage blading was injured by a bolthead from the segment carrying the fixed blading. This bolt was broken off, probably through having been set up too hard while assembling. These bolts were all tap bolts and have been replaced by fillister head screws with countersunk heads and a repetition of the accident would not be possible. The accident, however, was in no way peculiar to the electric drive as it might very well have happened to any other engine. The other repair was to replace one of the porcelain cylinders which carry the resistances; this cylinder was cracked when the ship went into dry-dock, but it was never discovered whether the cracking was due to the oiler putting undue pressure on the cylinder or due to some strain brought on it when the ship settled on the keel blocks. At any rate the damage was repaired by two machinists in about two hours.

The amount of work expended in keeping the equipment in condition has been very small. After coming in from a run, the turbine clearances are taken to see if they have changed; and the motor clearances are also checked; there

has been no change in either of these clearances up to date. Before getting under way the holding-down bolts of the turbine are gone over to see if they are tight, the slip rings on the rotor of the generator are examined to see if they are clean and all insulators are also examined for cleanliness, all connections are generally gone over to make sure they are tight, the oil switch boxes are examined to see if they have the proper amount of oil, and the governor control-valve springs are tested to see if they have the proper tension. After starting the turbine, the emergency trip is tested. In port the oil pump is run once a week to force oil through the turbine bearings and the motor shafts are jacked daily. Due to the fact that the main condenser is used a great deal (the auxiliary condenser being too small to handle the coaling winches), the small pump for draining the turbine casing is run for a few minutes each day when in port to make sure that no water may be allowed to accumulate in the turbine.

In operation the Jupiter's engines have been highly satisfactory. There has been only one time that anything has happened during the handling of the engines and that was the tripping out of an exciter. The lighting set was immediately put on for exciting and the engines were ready to use again in about one and one-half minutes. If such an accident were to happen again it would take even less time as the men are more familiar with the installation. At the time the incident occurred the ship had just left the navy-yard for the first time.

The handiness of the engines has been proved more than once; the ship has been handled a great deal in narrow waters and around docks. She steers very badly at times and the quick response of the engines has more than once helped in getting out of difficulties. The engines have been used to swing ship for compass deviation without putting any way on the ship at all, the total space used for swinging being little more than the ship's length.

The ability of the turbine to stand severe abuse from water has been demonstrated several times. There is no separator on the main steam line, and several times the boilers have primed and carried considerable water over into the turbine. This was particularly noticeable during dock trials when it was impossible to properly handle the boilers. The only indication the turbine gave was an increase in the first stage pressure and a rattle in the casing as the water was hurled through at a high rate of speed, but the turbine blading showed no signs of bad effects from this.

The backing qualities of the engines have proved to be all that could be desired; if the ship is cruising with the resistances in, the time taken for reversing is practically nothing at all; if the resistances are out, it takes a few seconds—not more than three.

When under way the engine-room is very cool, due to the fact that the generator is fitted with air impellers at each end which take their suction from the engine-room, thus ensuring a good circulation of air.

After all, the greatest test of the satisfactory working of any machinery is whether or not the men who are actually handling it and caring for it are pleased

with it. If this test applies to the Jupiter's machinery it certainly is an unqualified success. In particular is this true if the matter is referred to the coal passers in the fireroom, who have to handle much less coal than do the men on sister ships. The ship can make her contract speed of 14 knots without using forced draft at all.

DISCUSSION.

THE CHAIRMAN:—This most interesting paper is ready for discussion, and I trust there will be a very full and free expression of opinion. (A long pause.) It looks very much as if our engines of discussion needed warming up. I see before me a gentleman who has been most closely identified with this work, and greatly interested in it. He is also generally accredited as the sponsor for this mode of ship propulsion and entitled to most of the credit for results achieved. If he does not volunteer to come forward, I am afraid we will have to call on him by name. At other meetings of this Society, when questions of electric propulsion have been under discussion, much of our best information and most illuminating discussion has come from a member of this Society, whose career began at the U. S. Naval Academy, and whose subsequent successful work in civil life has shed luster on his *alma mater*. I think I may safely call on Mr. Emmet to give us an expression of opinion on the matter covered by the paper before us.

MR. W. L. R. EMMET, *Member of Council:*—My recent utterances before this Society on the subject of electric propulsion have consisted largely in railings at the officials of the Navy and others for not adopting it. But I no longer have that ground for complaint, inasmuch as the Navy Department has come out very handsomely in favor of electric propulsion lately. The officers of the Bureau of Steam Engineering have proceeded with great care and thoroughness to study the operations of the Jupiter. Admiral Griffin has sent his principal officers of the Bureau to see the Jupiter, one as commander and another to inspect her trials, and everything possible has been done to bring out the facts and all the interesting comparisons, and having made this investigation, Admiral Griffin has acted with positiveness and without reservation in his recommendations to the Department concerning the adoption of this method of propulsion for the battleship California.

The use of electricity for the propulsion of a ship is suggested simply by the superiority of the high-speed turbine, superiority not only in economy but in simplicity and in weight. It was about six years ago that I first advocated electric propulsion of warships, but long before that I and many others had thought of it as a possibility which might or might not be worth pursuing. I have always thought that there are thousands of possible engineering enterprises which a skilful engineer can develop to a high state of usefulness. The merit lies not in thinking the idea, but in bringing it to a thoroughly practical and useful application.

It was about the year 1897 or 1898 when we first made our arrangements with Mr. Curtis to build the Curtis turbines, or at least begin to experiment with the Curtis turbines. When the contract was drawn with Mr. Curtis, Mr. E. W. Rice, of the General Electric Com-

pany, put a clause in that contract relating to electric propulsion, that is, Mr. Curtis reserved the right to use his turbines for marine propulsion, but Mr. Rice wrote into the contract the words "except when through the medium of electric motors" or some words to that effect, showing that he considered electricity a possibility wherever power transmission had to be done in a compact, simple and reliable way.

The strength of the case of electric propulsion has steadily gained ever since I first discussed the subject before this Society, because high-speed turbines have become steadily better, and as they have become better they have become lighter and higher in speed, making more necessary suitable means of reducing the speed in any desired ratio. My first proposition to apply electric propulsion was in connection with a battleship, as I have always made it a practice in engineering to figure the best case first. I try to select the things on which to exert my energies which will bear the most fruit in a single operation rather than to take something in which the possible result is only a little better. I realized that the great merit of electric propulsion lay in its application to a battleship where there was necessity for high speed with a minimum of boilers, and where the desire for good economy at low cruising speed was very great.

When the question of equipping the Jupiter came up I rather protested against putting an electric plant into the Jupiter, because she was a ship of one speed, and while I knew I could make an enormous gain over any other propelling system in existence, I knew that the relative gain would be nothing like so great as if I could install the system on a battleship. The Jupiter requires about 7,000 horse-power, and is a very large, low-speed vessel. She runs practically at one speed, and there is no particular occasion for changing the ratio of speed in such a ship. The demonstration which has been made on the Jupiter is a very important one in marine engineering, and in spite of the fact that I did not consider it a desirable case, and hesitated to take it up lest we should not make a sufficiently striking demonstration, this paper reports the Jupiter as about 25 per cent better than her sister ships. The sister ships are as good as any ships afloat, with very good engines in them. The trials of the Cyclops showed what was considered a phenomenal performance, but the gain in the Jupiter is in reality, I think, more than is indicated by test, since her auxiliary arrangements are very imperfect and involve a great waste of steam. In the trials of the Jupiter the steam consumption for auxiliary purposes was reported as about 20 per cent. The reason for that was that in order to hold a good vacuum on the main unit they had to hold the pressure above the atmosphere on the auxiliaries, and were exhausting the auxiliaries into the main condenser. The auxiliary economies running with back pressure were extremely bad—turbine units, some of them—and the steam consumption was outrageous.

There are one or two things in Mr. Robinson's paper relating to the Jupiter I think I might explain. The breaking of a bolt in the first stages of the Jupiter when she was on her trial was probably due to the fact, as he mentions in another part of the paper, namely, that there was an immense amount of water passed through the turbine by violent priming. There was so large an amount of boiler compound in the boiler that the outside of the turbine was encrusted with solids from the boiler compounds which primed over into the turbine and was forced out at the valve stem. The shock from this water undoubtedly broke the head off one of three bolts that held the stationary buckets. The ship came in under her own steam with the bolt broken. That illustrates a great advantage of a turbine of this type, which is practically nine separate turbines in separate cases. If anything happens to one of them, you can lift off the top and clear that element so that it will run, and the remainder

of them will run the ship with only slightly less efficiency. Another point is that an electrical alternator is not exactly a unit, but is an assembling of a great number of magnetic circuits, in separate coils, and is not likely to be injured so it cannot be reconnected in some way so that it will run by a man who understands. I guarantee that I can give a man a little while with a pickaxe on the Jupiter's electrical apparatus, and if I had a few hours at it I would get it running again, because there are ways of doing these things. People who understand that kind of electrical apparatus can do all sorts of things with it which would seem to be most difficult at a glance to the layman.

The comparison which is now most interesting in this connection is that with the geared turbine, which has become most important as a method of ship propulsion. From the demonstrations which have been made with both of these methods, it is obvious that no ship should be run with reciprocating engines or direct turbine drive. The geared turbine is subject to various limitations, as compared with the electric drive method, which have sometimes been overlooked. I had a geared turbine set running in Schenectady driving a 500-kilowatt generator. I decided to determine what the losses in reversing a turbine would be, so I ran the generator as a motor, first in one direction with various pressures, with various degrees of vacuum in the casing, and then in the other direction with the same conditions. We delivered 10 kilowatts to the motor by running the turbine ahead and delivered over 70 kilowatts to the motor by running it backward, that is, against the direction of the buckets. It appears, therefore, that turning these buckets in the reverse direction takes some power. The degree of this loss will depend upon circumstances, and in some of the higher speed and best turbines the loss will be very considerable. If, however, we want the best we cannot make concessions in the design of the turbines; we must go to the limit in speed and in every characteristic, or else we will lose more than the electrical losses. The mechanical losses of the gears amount to something, maybe a per cent or two, and the additional number of bearings involved through the necessity of alignment of the gearing and the supporting of weights and thrusts or pressures from the gears involve additional losses. The reversing turbine, as has been stated, involves losses, and if it is to give powerful and effective reversing power, which is important on any ship, its losses will be considerable. The electrical losses in the California design represent less than 8 per cent, and the turbines are of ideal efficiency.

To give you a conception of how such a turbine compares with the turbines used to propel ships, there is a large turbine which we are operating here in New York, and tested within the last few days, which delivers 30,000 kilowatts. At about 25,000 kilowatts, or possibly 27,000 kilowatts, two of these machines would be capable of driving the Lusitania. The efficiency of that machine is 75 per cent of the theoretical work in the steam, that is, delivered electrically to the busbars. If we took the electrical losses out of that, which will amount to about 5 per cent, we will raise that to about 77 or 78 per cent. The Lusitania's turbines, which I suppose are the most efficient marine turbines in the world, are about 63 per cent efficient, so you have a comparison of two things, for the same purpose, except for the auxiliary arrangements of the turbine of 78 per cent efficiency, as against the one of 63 per cent efficiency and in such a case the electrical losses could be at least compensated for by using lower speed propellers which would be much more efficient. The Jupiter's turbine is not so good as that, quite, because it is not so large, and it is only in the largest turbines we can get the best results. The California's turbines at the best speeds will be almost as good as this highly efficient machine which I have mentioned.

In turbine drive of ships you can make practically no concessions as to the speed of the

turbine, or, for that matter, you can make no concessions as to the speed of the propeller, without sacrificing the electrical losses.

In the study I made of the Pennsylvania, the Bureau of Steam Engineering made a study of propeller possibilities on that ship for our company, in order that I might look into the possibilities of the case. They showed that the efficiency with four propeller shafts on the Pennsylvania, operating at 160 revolutions per minute, which, I proposed, was about 8 per cent better than operating at 222 revolutions per minute, which is to be used on the turbine-driven Pennsylvania. The turbines which are going into the Pennsylvania have an efficiency of about 61 per cent, I should judge, at full speed, and the turbines that I am putting into the California have an efficiency of about 75 per cent, and the difference of propeller efficiency in our favor would compensate for the electrical losses.

Mr. John F. Wentworth, *Visitor*:—I did not come prepared to do any speaking on any but my own line, but in connection with this subject I hope the fight will be carried, and am interested in having it carried, into the enemy's camp. I would like to point out one or two facts here. For instance, we read that the fuel consumption per steam horse-power varied from 1.66 to 2.50 pounds of coal per hour, but from what goes above, I take it that is on the turbine; in other words, the efficiency of the turbine is around 11 per cent. That means that you are using 11 pounds of coal and throwing away 89 pounds of coal.

As far as comparing different ships goes, it reminds me a good deal of an experience I had in Washington one time. I ran up against a man whom I tried to get to back me. He had some mining machinery of some kind on the Potomac River, and had some stamps up there. He had an idea about the efficiency to be obtained by using water as a fuel. He said that these stamps were using the full capacity of the boilers, and he had to do something, so he was going to put water under the boilers in connection with his fuel, put in more stamps, and show clearly that he obtained energy from decomposition of the water, and subsequently reunition again of the hydrogen and oxygen. The joke was this man actually claimed to have demonstrated by results the saving from "burning water." It seems to me in an engineering proposition the whole thing should be gotten down to the factor of the coal pile or the oil tank, so that we know where we stand. To state that a turbine is 75 per cent efficient, it seems to me, is misleading. I do not quite understand what that means, but it is a fact when you shovel your coal under the fire and take your load off the shaft, you only have 11 per cent.

I would like to ask a few questions. Why not investigate the possibilities of the internal-combustion engine as it can be developed when considered as a thermodynamic problem? Cannot the oil engine be built in low-pressure type without a sacrifice of efficiency? Cannot this type be built in cylinder sizes of 60-inch to 72-inch bore? Cannot this type of oil engine run at all the piston speeds now used in reciprocating steam engines? Cannot this type of plant show a greater efficiency at partial load than any known plant? I believe all this to be possible.

Is it not a fact that in the proposed electric plant in order to produce 1,000 horse-power in the motor it is necessary to have over 1,050 horse-power in the generator, 1,100 horse-power in the turbine, and boilers large enough to drive these turbines? Does this not mean 3,150 horse-power in the machinery to produce 1,000 horse-power on the shaft, besides the boiler?

Suppose your steam plant has an efficiency of 14 per cent, do you not lose 10 per cent of this, owing to the extra machinery interposed? Then, again, do you not lose around another 10 per cent on account of the interest charges on this extra plant? I think you do. Then, again, where your steam-engine efficiency is limited to around 12 per cent, is it not possible to build a reciprocating oil engine in which the efficiency (based on brake horse-power) shall be over 36 per cent, and perhaps over 40 per cent? I think this will be found to be true, if thoroughly investigated. By that I mean, analyze your fuel, get your British thermal units, multiply your British thermal units by 778, and get your foot-pounds of energy in one pound of coal, then divide these foot-pounds by 60×33,000; that will give you the horse-power hour that you can get out of 1 pound of oil for 100 per cent efficiency, and you will find you will have to use perhaps 2.5 pounds of oil to get the work that you figure out from 1 pound of oil (this is for an oil engine 40 per cent efficient).

What can the constructor and ordnance expert not do with this saving in fuel weight and machinery weight, or what can the tactician not do with this increased radius of operation? The solution of the problem of coaling at sea shows up the advantage of fuel economy in that connection.

Is it worthy of the engineer to waste his time and to spend such amounts in unnecessary machinery for a gain of fractional percentages in efficiency, and disregard the possibility of an increase of 300 per cent in efficiency coupled with a corresponding increase in either speed, steaming radius, or offensive and defensive qualities, or a happy combination of these three factors producing a better all-round battleship?

Mr. Luther D. Lovekin, *Member*:—I have taken quite an interest in this proposition of electric drive during the last year. I have sympathized with Mr. Emmet very much in the past five years in his efforts in the direction of introducing the electrical propulsion for battleships, and I congratulate him now on the success which he has thus far achieved. Recently I have had occasion to engineer some vessels, one of them about 8,000 horse-power, and one of much larger power. I investigated the geared turbine proposition, one of which we are building, using oil fuel. I also investigated the oil-engine proposition, and last, but not least, the electric drive. The oil engine has many disadvantages, contrary to the statements of the previous speaker. We know that an oil engine runs at about ½ pound of oil per horse-power, and we also know that we have geared turbines now that can go on 1 pound of oil per horse-power, for all purposes, so that there is hardly a ratio of three to one. With the electric drive we can do equally well.

As regards the efficiency, I have not gone into that question very deeply, but I know it is more than 11 per cent, or we would not be using it. The great advantage that we found in the electric drive for high powers over others was in the high propulsive efficiency we could get.

In Mr. Robinson's paper, where he refers to the advantages due to the use of twin screws, exception might be taken to the statement of twin screws being used on battleships of large power, but inasmuch as I have had occasion quite recently to design an installation of power in which 45,000 brake horse-power could be used on one screw, and yet retain its efficiency, I think that for our Navy, at least, we can count on twin screws being entirely within reason. There is no doubt about our being able to use twin screws for a battleship of at least 90,000 brake horse-power. Of this I am positive.

As regards fuel consumption, I feel safe in stating that we can get along with less

than 1 pound of oil per horse-power for all purposes. This does not constitute the main unit alone, but all units, auxiliaries included. Our figures have proven this beyond all doubt.

Another advantage with the electric drive is the fact that you can make a really electrical battleship, using your power at the very conservative rate of, say, 1 pound of oil per horse-power, and using very efficient turbines for generating the current for driving the auxiliary machinery, instead of using from 100 to 200 pounds of steam per horse-power, as we are doing to-day in lots of our auxiliaries on battleships.

I feel it my duty to move that this Society offer its congratulations to Mr. Emmet for his painstaking work in bringing about a new means of propelling vessels, and particularly battleships, which marks a new epoch in marine engineering and goes far into that most important question of the day, viz., the conservation of our natural resources.

I think Mr. Emmet has done more than any one else to bring about that result.

Mr. E. A. Stevens, Jr., *Member:*—I do not agree with Mr. Emmet in what he said about the reciprocating engine no longer having a place on board ships. There are places where, I think, the use of this type of engine will never be abandoned, especially in slow-speed work, and on vessels handled by crews that are paid small wages, such as tugs, small tramp steamers, etc. It is true you can get better economy with a geared turbine or with Mr. Emmet's electric propulsion system, but I do consider that a high-speed machine, such as this turbine, relying on force lubrication and close attention for its satisfactory operation, should never be put into such hands. Therefore I think what Mr. Emmet has said about the reciprocating engine is a little far-fetched.

In regard to the economy of the Jupiter, I would like to call your attention to page 190 of this paper where Lieutenant Robinson states that the propellers were designed by Captain Dyson, and showed a high efficiency of propulsion, from 300 to 800 horse-power less than her sister ship. I take this to mean that at the lower speed she drove with 300 horse-power less, and at the higher speed 800 horse-power less. Looking at the result of the trial, we find the Jupiter took a little over 7,000 horse-power (on the propeller). The saving in power alone due to the propellers is over 10 per cent, leaving less than 15 per cent saving (of fuel) due to the type of machinery.

What Lieutenant Robinson has said about the economy of the Jupiter would equally apply to geared turbines, especially at the higher speeds. I do not think, however, that there would be much difference in favor of the electric propulsion, at the lower speeds, as the efficiency of the electric machinery would not be as great as at the higher powers, while the losses in the gears would not vary much. I do not believe that any reduction can be made in the crew, for whatever is saved in the number of machinists carried, if any, will have to be supplanted with electricians. In the case of any electrical trouble the help that would be rendered by most marine engineers would be of little assistance, as I am quite sure that most of them know very little about electricity. What they do know they have learned in connection with small plants, electric lighting, air compressors, winches, etc., such as are used on vessels. They would, however, know very little about an electric power plant generating and using several thousand horse-power, with its complicated accessories. Some people contend, if more were known about electricity by marine engineers, that this system of propulsion would be more popular. Be that as it may, I fully believe that if they did know more about electricity, they would be less likely to want it as a means of propulsion.

Mr. Ernest H. B. Anderson, *Member:*—I have read this paper with a great deal of interest, and while the author puts forward a good case for the electric drive, yet it does not seem to me that any great naval power can properly make an experiment using the electric drive for the propelling machinery installation of a modern battleship, taking into consideration the fact that only one of these electrical installations has yet been tried, and that on a smaller vessel and with a very much simpler layout.

As the author points out, there are many methods of ship propulsion, but for the larger size of battleships and battleship cruisers, there are only two methods which are being seriously considered: first, turbine machinery of the direct drive; and second, high-speed turbines and mechanical reduction gears.

The former needs no comment, as it is general knowledge that there are turbine machinery installations of the direct-drive type now at sea which develop about 100,000 shaft horse-power and drive large vessels at speeds in excess of 30 knots.

The latter system is making equally as rapid progress as the direct-turbine drive in practically all classes of vessels, and there is now under construction geared turbine machinery of which the horse-power to be transmitted through one line of shafting is equally as great as that per shaft of the largest direct-drive turbine installations.

Referring to the author's paper, I do not like the idea of using one generator in a battleship to supply current to four motors driving separate shafts for speeds up to 19 knots, and I feel certain that, under regular battleship steaming conditions with the other vessels of the fleet, such a scheme will be found impracticable.

Independent control over each shaft is preferable, and this is obtained with an installation of high-speed turbines and gearing.

Nothing is stated regarding the type of drive for the auxiliary machinery units used in conjunction with the generating set, but it is presumed that those directly operated with the main engines will be motor driven.

I understand this type has not proven entirely satisfactory in power stations, unless steam-driven sets are also installed for stand-by purposes, and on board ship the latest battleships are now using steam turbines to drive the boiler-room blowers for the forced draft system.

As regards reliability, nothing but years of extended service will prove this, but it is worthy of notice that the Jupiter has not been free from the somewhat regular accidents common to every type of marine engine.

Backing or astern turbines are not giving any trouble due to blade strips, and I have not seen a case of a blade strip in any one of the four United States battleships which have reaction turbines.

As regards economy, the trial data of the Jupiter do not appear to show any special gain either in the water measurements or in the coal consumption records.

Dealing with the questions of space and weight, it is somewhat difficult to say anything definite on these points until one has a case to consider, but I believe the new design of motor proposed for a battleship will weigh considerably more than the type of motor in the Jupiter. I believe any advantage in weight would be largely in favor of the all-gear turbine drive.

For a battleship of 33,000 shaft horse-power and 21 knots, the weight of the turbine only for a four-shaft direct drive varies from 550 to 600 tons, and for a four-shaft all-gear installation from 320 to 350 tons.

I strongly recommend all interested in this subject to read Lieutenant Robinson's papers in the Journal of the American Society of Naval Engineers for November, 1913, and May, 1914, which deal largely with the Jupiter, and in one of them the author specially refers to the question of personnel, which is a vital factor in the ultimate success of this form of drive.

Lieutenant Robinson, his brother officers and mechanics are to be heartily congratulated on the great success they have achieved with the pioneer installation of electric motors for propelling a large ocean-going vessel.

MR. WENTWORTH (Communicated):—Mr. Lovekin, following me in this discussion, took the stand of doubting my hurried figures as to the efficiency of the turbo-electric plant described by Lieutenant Robinson. I have confidence, as we all should, that data presented before such a Society as this should be as carefully prepared as possible. The following substantiates the statement made on the floor.

Efficiency at 1.66 pounds of coal per horse-power hour (48-hour test):

$$33{,}000 \times 60 = 1{,}980{,}000 \text{ foot-pounds per horse-power hour}$$

divided by—

$$14{,}000 \times 1.66 \times 778 = 18{,}080{,}000 \text{ foot-pounds per horse-power hour in fuel used.}$$

$$1{,}980{,}000 \div 18{,}080{,}000 = 10.95$$

per cent actual efficiency based on Mr. Robinson's figures.

Efficiency based on 2.50 pounds of coal per horse-power hour (24-hour test):

$$\frac{33{,}000 \times 60}{14{,}000 \times 2.50 \times 778} = \frac{1{,}980{,}000}{27{,}200{,}000} = 7.3 \text{ per cent efficiency.}$$

Allowing a calorific value of 14,000 for the coal used, the efficiency on the discussed plant would run from 11 to 7 per cent. If the coal were higher grade the efficiency ranges would be less and greater with inferior grades of coal.

Assuming that the vessel in question had been equipped with oil-burning boilers and assuming that the figures presented in the paper of the writers on the oil engine to be correct, 1 pound of oil in the oil engine would do the work of from 3.50 to 5 pounds of oil in a turbo-electric plant similar to the one described. This comparison is more favorable than the one made on the floor, where 1 pound of oil in the oil engine was only considered to be equal to 3 pounds of oil in the turbo-electric plant.

This is a small matter to bring up, but the writer has endeavored to always take care in making statements of an engineering nature and to confine himself to such statements as he could show figures to substantiate.

THE CHAIRMAN:—It is unfortunate that the author of this most interesting paper is not present. Members were rather reluctant to begin this discussion, but seem to have gotten a good headway after beginning.

The resolution offered by Mr. Lovekin, while undoubtedly sympathetically received by most of us, is of a character the Chair will not put as a motion at this time, because chairmen are very reluctant to set precedents. But we can most heartily—we have already done so, in fact; and I am sure we will do it again—express our great appreciation of the work done by Mr. Emmet in making possible what I cannot help but feel is an epoch-making performance in marine propulsion. I am very kindly disposed to all three methods of propulsion, but in the brief period during which this particular method has been under trial, I have

felt that it has made more substantial progress than any other form with which I have acquaintance; but I sincerely trust that all the other forms of propulsion will also make advances, and that each one will stimulate the other, so that in the end we will get the very best results, and after a certain further experience know definitely which is the most advantageous for our ships of war.

The attitude assumed by the author of the paper, who has been intimately associated with the actual performance of this system of propulsion, is most commendable; he has undoubtedly drawn his conclusions from the actual working of the machinery under his supervision, and, so far as the records indicate, the results have been exceedingly satisfactory.

All the comments made in this discussion will, of course, be transmitted to the author of the paper, and he will have an opportunity of submitting his comments in response. I think the Society is to be congratulated not only upon the paper, but upon having in its membership one who has accomplished such very fine results in such a comparatively limited period of time; we are also fortunate in having had the very active and earnest co-operation of the Navy Department and the Bureau of Steam Engineering in giving practical trial to this method of propulsion, and their having the courage to continue to give it further trial on an even greater scale.

Lieutenant Robinson (Communicated):—1. In regard to the question of oil engines, which has been raised, I would refer back to the title of this paper which shows that it is intended to deal only with the propulsion of battleships. In its present state of development the oil engine is out of the question for this purpose; no predictions are made as to what the future may bring about in its development. In the first place, oil engines have not been built in sizes that would make them available for battleships, and in the second place their reliability is at present so poor as to unfit them for this purpose.

2. In regard to the economy of the plant of the Jupiter, I do not think there is any question of the great gain made over other ships of this class. There are at present seven colliers in our service of practically the same hull and displacement as the Jupiter. Next to the Jupiter, the most efficient of these ships is the Cyclops, which has an identical hull and boiler plant with that of the Jupiter, the two ships having been built from the same plans. There is herewith given the following comparison of the two ships. The data are taken from the average performance of the vessels while in actual service:—

Speed in knots.	Tons of coal used per day.	
	Jupiter.	Cyclops.
10	50.5	78
11	57	81.5
12	66.5	87
13	81.5	93

3. Doubt has been expressed as to the feasibility of using one generator on a battleship to supply power for the motors at low speeds, but no reason was advanced for questioning this.

The Jupiter is equipped with only one turbine, uses that up to speeds of 15 knots, and her maneuvering qualities are certainly better than any ship we have in the fleet at present, so I see no reason to doubt the success of maneuvering a battleship with one turbine at low speeds.

4. The question of personnel has been raised, and not wishing to go into this too deeply, I will simply state that the personnel of the Navy is perfectly capable at the present time of handling electric propulsion on board ship. The mechanics and electricians on the Jupiter were in no way picked out for this duty, but were simply men who were available at that time.

THE CHAIRMAN:—Gentlemen, we have come to the conclusion of our set program of papers. I wish the Acting President were here to give you his congratulations on the very interesting character of our meeting. However, you will have an opportunity to see him again to-night.

Our President, Colonel Thompson, as the Acting President advised you at the opening meeting, is unfortunately detained in Washington by illness. His absence from these meetings has been a real disappointment to us, and the Secretary has just handed me a letter from Colonel Thompson, which I will read:—

WASHINGTON, D. C.,
December 9, 1914.

"DEAR MR. COX:

"I have made every effort to attend the meetings, and especially the dinner of The Society of Naval Architects and Marine Engineers, but a cruel and unsympathetic doctor has absolutely denied me permission.

"Will you say to the members present at the meeting, or at the dinner, that I have felt the honor they conferred upon me in making me their president as one of the crowning honors that have come to me in my lifetime, and I have deeply regretted that the condition of my health has made it impossible for me to properly perform my duties. My heart has been in the work; the spirit has been very willing, but the flesh, alas! is too weak.

"Pray present my apologies to all, and extend my best wishes to each and every member for a Merry Christmas and a Happy New Year.

Very truly yours,
ROBERT M. THOMPSON."

THE CHAIRMAN:—I feel quite sure that all of us sympathize deeply with Colonel Thompson in his illness, and that every one of us greatly regrets that he could not have been with us, and that you will most heartily authorize your Secretary to acknowledge this communication, reciprocating the good wishes of Colonel Thompson, and expressing our very deep regret at his inability to be present.

Gentlemen, the meeting is now adjourned *sine die*. I trust that we will all see each other again at our dinner at seven o'clock this evening.

The meeting then adjourned.

APPENDIX

INTERNATIONAL CONVENTION RELATING TO SAFETY OF LIFE AT SEA

(Reprinted from Senate Document No. 463, 2d Session, 63d Congress, with addition of Resolution passed by the Senate on December 16, 1914)

[Resolution passed by the Senate of the United States during the 3d Session of the 63d Congress.]

SAFETY OF LIFE AT SEA.

Resolution Advising and Consenting to Ratification Adopted December 16, 1914.

December 16, 1914.—Injunction of secrecy removed and resolution ordered printed.

Resolved (two thirds of the Senators present concurring therein), That the Senate advise and consent to the ratification of the international convention on the safety of life at sea, signed at London on January 20, 1914, with the regulations, final protocol, and recommendations connected therewith: Provided, that the United States reserves the right to abrogate "treaties, conventions, and agreements" indicated in article 68, in accordance with the terms of such treaties, conventions, and agreements, and to impose upon all vessels in the waters of the United States such higher standards of safety and such provisions for the health, protection and comfort of passengers, seamen, and immigrants as the United States shall enact for vessels of the United States.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES

TRANSMITTING

AN AUTHENTICATED COPY OF THE INTERNATIONAL CONVENTION RELATING TO SAFETY OF LIFE AT SEA, THE DETAILED REGULATIONS THEREUNDER, A FINAL PROTOCOL, AND THE "VOEUX" EXPRESSED BY THE CONFERENCE, ALL SIGNED AT LONDON JANUARY 20, 1914.

MARCH 17, 1914.—Message read; convention read the first time and referred to the Committee on Foreign Relations, and, together with the message and accompanying papers, ordered to be printed in confidence for the use of the Senate.
MARCH 25, 1914.—Injunction of secrecy removed.

To the Senate:

I transmit herewith, to receive the advice and consent of the Senate to ratification, an authenticated copy of the International Convention Relating to Safety of Life at Sea, the detailed regulations thereunder, a final protocol, and the "Voeux" expressed by the conference, all signed at London, January 20, 1914.

The attention of the Senate is invited to the accompanying report of the Secretary of State.

WOODROW WILSON.

THE WHITE HOUSE,
Washington, March 17, 1914.

THE PRESIDENT:

The undersigned, the Secretary of State, has the honor to lay before the President for transmission to the Senate, if his judgment approve thereof, with a view to receiving the advice and consent of the Senate to their ratification, an authenticated copy of the International Convention Relating to Safety of Life at Sea, of the detailed regulations thereunder, and of a final protocol, and of the "Voeux" expressed by the conference, all signed at London on January 20, 1914.

The convention embodies the unanimous conclusions of the International Conference on Safety of Life at Sea which met at London from November 12, 1913, to January 20, 1914. The conference was comprised of the representatives of the 14 principal maritime nations and of three of the self-governing British dominions. It was called in a large measure upon

the suggestion of the Government of the United States, and the advice of the American delegation was influential upon a great many particulars which entered into this convention. The conference was composed of men trained to the sea and experienced in the administration of the laws relating to maritime affairs, and its unanimous conclusions carry weight on the matters of which the convention treats. The American delegates, who took an active part in the framing of every article and regulation of the convention, are agreed that the international standards for the safety of life at sea thus proposed to be established are higher than those of any nation now in force, and that the ratification of the convention will secure benefits for humanity by the joint action of maritime nations which could not be accomplished by any one nation, however powerful upon the sea. There are probably points in detail in which the convention may be criticized, especially by particular interests, but in its entirety it is high testimony to the will and ability of nations to put aside special and local considerations in order to promote the progress and welfare of mankind. By its terms the ratifications shall be deposited not later than December 31, 1914. Early and favorable action, accordingly, is recommended.

Respectfully submitted.

W. J. Bryan.

Department of State,
Washington, D. C., March 13, 1914.

[TRANSLATION]

INTERNATIONAL CONVENTION ON THE SAFETY OF LIFE AT SEA

CONVENTION

PREAMBLE.

His Majesty the German Emperor, King of Prussia, in the name of the German Empire; His Majesty the Emperor of Austria, King of Bohemia and Apostolic King of Hungary; His Majesty the King of the Belgians; His Majesty the King of Denmark; His Majesty the King of Spain; the President of the United States of America; the President of the French Republic; His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Possessions beyond the Seas, Emperor of India; His Majesty the King of Italy; His Majesty the King of Norway; Her Majesty the Queen of the Netherlands; His Majesty the Emperor of all the Russias; His Majesty the King of Sweden; having recognized the desirability of establishing by common agreement certain uniform rules with respect to the safety of life at sea, have decided to conclude a Convention for this purpose, and have appointed as their Plenipotentiaries the following:

H. M. THE GERMAN EMPEROR, KING OF PRUSSIA, in the name of the German Empire:

His Excellency Dr. von Koerner, Privy Councilor, Director of the Commercial Section of the Imperial Foreign Office

Dr. Seeliger, Privy Councilor of Legation, Counsel to the Imperial Foreign Office.

Schütt, Privy Councilor of the Government, Councilor to the Imperial Department of the Interior

Dr. Riess, Privy Councilor of the Government, Member of the Imperial Insurance Department

Professor Pagel, Director of the Classification Society "Germanischer Lloyd"

Schrader, High Privy Councilor for the Imperial Post Office, Counsel to the Imperial Post Office Department

Rear Admiral Behm (retired), director of the German Hydrographical and Meterological Bureau

H. M. THE EMPEROR OF AUSTRIA, KING OF BOHEMIA AND APOSTOLIC KING OF HUNGARY:

Baron G. de Franckenstein, Councilor of Legation and Director of Commercial Affairs of the Embassy of Austria-Hungary at London.

Paul Schreckenthal, Doctor of Laws, Secretary to the Imperial and Royal Austrian Ministry of Commerce

Ladislaus Dunay, Councilor of the Bureau of the Royal Hungarian Maritime Administration at Fiume

H. M. THE KING OF THE BELGIANS:

E. A. Pierrard, Director General of Marine in the Department of Marine, Posts and Telegraphs
Ch. Le Jeune, President of the International Maritime Committee
L. Franck, Barrister, Member of the House of Representatives, Vice President of the International Maritime Committee

H. M. THE KING OF DENMARK:

A. H. M. Rasmussen, Director of Instruction of State Engineers
Emil Krogh, Chief of Bureau in the Ministry of Commerce and Navigation
Höst, Director of the United Steamship Company, Ltd.
V. Topsöe-Jensen, Deputy Chief of Bureau and Secretary of the Department of Justice

H. M. THE KING OF SPAIN:

Captain Don Rafael Bausá, Chief of the Spanish Naval Commission at London

THE PRESIDENT OF THE UNITED STATES OF AMERICA:

J. W. Alexander, Member of the House of Representatives
T. E. Burton, United States Senator
J. Hamilton Lewis, United States Senator
E. T. Chamberlain, Commissioner of Navigation
Captain Commandant E. P. Bertholf, Revenue-Cutter Service
Chief Constructor Washington L. Capps, Rear Admiral, U. S. N.
Captain George F. Cooper, U. S. N., Hydrographer
Homer L. Ferguson, General Manager of the Newport News Shipbuilding and Dry Dock Company
Alfred Gilbert Smith, Vice President of the New York and Cuba Mail Steamship Company
Captain Wm. H. G. Bullard, U. S. N., Superintendent of the Naval Radio Service
George Uhler, Supervising Inspector General, Steamboat-Inspection Service

THE PRESIDENT OF THE FRENCH REPUBLIC:

Monsieur Guernier, Professor of Political Economy at the University of Lille, Member of the Chamber of Deputies, Vice President of the Committee on Marine Affairs of the Chamber of Deputies, Vice President of the Higher Council of Maritime Navigation

H. M. THE KING OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND and of the British Possessions beyond the Seas, EMPEROR OF INDIA:

Lord Mersey, former President of the Admiralty Division of the High Court of Justice and President of the Court of Inquiry on the loss of the steamship Titanic
E. G. Moggridge, Assistant Secretary of the Board of Trade for the Marine Department

Sir Archibald Denny, Bart., Chairman of the Departmental Committee on Bulkheads and Watertight Compartments
Sir Norman Hill, Chairman of the Merchant Shipping Advisory Committee
Sir John Biles, LL.D., D. Sc., former Chairman of the Departmental Committee on Boats and Davits
Captain Acton Blake, Deputy Master of Trinity House
Captain A. H. F. Young, Professional Officer to the Marine Department of the Board of Trade
C. Hipwood, of the Marine Department of the Board of Trade
W. D. Archer, Principal Ship Surveyor of the Board of Trade
For Australia—
Captain R. Muirhead Collins, Official Secretary of the Commonwealth of Australia at London
For Canada—
Alexander Johnston, Deputy Minister of Marine and Fisheries
For New Zealand—
Thomas Mackenzie, High Commissioner of the Government of New Zealand at London

H. M. THE KING OF ITALY:

Carlo Bruno, Director General of the Merchant Marine in the Department of the Marine
Major General Vittorio Ripa di Meana, of the Naval Constructors
Gustavo Tosti, Doctor of Laws, Consul General

H. M. THE KING OF NORWAY:

Harald Pedersen, Director of the Bureau of the Merchant Marine
Dr. Johannes Bruhn, Director of the "Norske Veritas" Classification Society
Jens Evang, Secretary in the Foreign Office

H. M. THE QUEEN OF THE NETHERLANDS:

J. V. Wierdsma, Chairman of the Committee of Directors of the Netherlands-American Steamship Company
H. S. J. Maas, Consul General of the Netherlands at London
A. D. Muller, Inspector General of Navigation
J. Wilmink, Director of the Royal Netherlands Lloyd's Steamship Company
J. W. G. Coops, Chief of Division, Department of Agriculture, Industry and Commerce

H. M. THE EMPEROR OF ALL THE RUSSIAS:

N. de Etter, Counselor of the Embassy at London

H. M. THE KING OF SWEDEN:

Vice Admiral Olsen, former President-General of the Naval Service
N. G. Nilsson, Inspector of Lifesaving Appliances in the Department of Commerce

who, having been duly authorized to that effect, have met in conference at London and have drawn up by common consent the following Convention:

Chapter I.—Safety of Life at Sea.

Article 1.

The High Contracting Parties undertake to give effect to the provisions of this Convention, for the purpose of securing safety of life at sea, to promulgate all regulations and to take all steps which may be necessary to give the Convention full and complete effect.

The provisions of this Convention are completed by Regulations which have the same force and take effect at the same time as the Convention. Every reference to the Convention implies at the same time a reference to the Regulations annexed thereto.

Chapter II.—Vessels to which this Convention Applies.

Article 2.

Except where otherwise provided by this Convention, the merchant vessels of any of the States of the High Contracting Parties which are mechanically propelled, which carry more than 12 passengers and which proceed from a port of one of the said States to a port situated outside that State, or conversely, are subject to the provisions of this Convention. Ports situated in the Colonies, Possessions or Protectorates of the High Contracting Parties are considered to be ports outside the States of the High Contracting Parties.

Persons who are on board by reason of force majeure or in consequence of the obligation laid upon the master to carry shipwrecked or other persons are not deemed to be passengers.

Article 3.

There are excepted from this Convention, save in the cases where the Convention otherwise provides, vessels making voyages specified in a schedule to be communicated by each High Contracting Party to the British Government at the time of ratifying the Convention.

No schedule may include voyages in the course of which the vessels go more than 200 sea miles from the nearest coast.

Each High Contracting Party has the right subsequently to modify its schedule of voyages in conformity with this Article on condition that it notifies the British Government of such modification.

Each High Contracting Party has the right to claim from another Contracting Party the benefit of the privileges of the Convention for all of its vessels which are engaged in any one of the voyages mentioned in its own schedule. For this purpose the Party claiming such benefit shall impose on the said vessels the obligations prescribed by the Convention in so far as, having regard to the nature of the voyage, these obligations would not be unnecessary or unreasonable.

Article 4.

No vessel, not subject to the provisions of the Convention at the time of its departure, can be subjected to the Convention in the course of its voyage, if stress of weather or any

other cause of force majeure compels it to take refuge in a port of one of the States of the High Contracting Parties.

Chapter III.—Safety of Navigation.

Article 5.

When the expression "every vessel" is used in this Chapter and in the corresponding part of the annexed Regulations, it includes all merchant vessels whether they are the vessels defined in Article 2 or not which belong to any of the Contracting States.

Article 6.

The High Contracting Parties undertake to take all steps to insure the destruction of derelicts in the northern part of the Atlantic Ocean east of a line drawn from Cape Sable to a point situated in latitude 34° north and longitude 70° west. Further, they will establish in the North Atlantic with the least possible delay a service for the study and observation of ice conditions and a service of ice patrol. For this purpose:

Two vessels shall be charged with these three services.

During the whole of the ice season, they shall be employed in ice patrol.

During the rest of the year the two vessels shall be employed in the study and observation of ice conditions and in the destruction of derelicts; nevertheless the study and observation of ice conditions shall be effectively maintained, in particular from the beginning of February to the opening of the ice season.

While the two vessels are employed in ice patrol the High Contracting Parties, to the extent of their ability and so far as the exigencies of the Naval Service will permit, will send warships or other vessels to destroy any dangerous derelicts, if this destruction is considered necessary at that time.

Article 7.

The Government of the United States is invited to undertake the management of the three services of derelict destruction, study and observation of ice conditions, and ice patrol. The High Contracting Parties which are specially interested in these services, and whose names are given below, undertake to contribute to the expense of establishing and working the said services in the following proportions:

	Per cent.		Per cent.
Austria-Hungary	2	Italy	4
Belgium	4	Netherlands	4
Canada	2	Norway	3
Denmark	2	Russia	2
France	15	Sweden	2
Germany	15	United States of America	15
Great Britain	30		

Each of the High Contracting Parties has the right to discontinue its contribution to the expense of working these services after the 1st September, 1916. Nevertheless, the High Contracting Party which avails itself of this right will continue responsible for the

expenses of working up to the 1st September following the date of denunciation of the Convention on this particular point. To take advantage of the said right, it must give notice to the other Contracting Parties at least six months before the said 1st September; so that, to be free from its obligations on the 1st September, 1916, it must give notice on the 1st March, 1916, at the latest, and similarly for each subsequent year.

In case the United States Government should not accept the proposal made to them, or in case one of the High Contracting Parties, for any reason, should not assume responsibility for the pecuniary contribution defined above, the High Contracting Parties shall settle the question in accordance with their mutual interests.

The Government of the High Contracting Party which undertakes the management of the service of derelict destruction is invited to devise means of granting, at the expense of this service, to merchant vessels, which have contributed in an effective manner to the destruction of ocean derelicts, rewards to be fixed by the Government in accordance with the services rendered.

The High Contracting Parties which contribute to the cost of the three above-mentioned services shall have the right by common consent to make from time to time such alterations in the provisions of this Article and of Article 6 as appear desirable.

Article 8.

The master of every vessel which meets with dangerous ice or a dangerous derelict is bound to communicate the information by all the means of communication at his disposal to the vessels in the vicinity, and also to the competent authorities at the first point of the coast with which he can communicate.

Every Administration which receives intelligence of dangerous ice or a dangerous derelict shall take all steps which it thinks necessary for bringing the information to the knowledge of those concerned and for communicating it to other Administrations.

The transmission of messages respecting ice and derelicts is free of cost to the vessels concerned.

It is desirable that the said information should be sent in a uniform manner. For this purpose, a code, the use of which is optional, appears in Article I of the Regulations annexed hereto.

Article 9.

The master of every vessel fitted with a radiotelegraph installation, on becoming aware of the existence of an imminent and serious danger to navigation, shall report it immediately in the manner prescribed by Article II of the Regulations annexed hereto.

Article 10.

When ice is reported on, or near, his course, the master of every vessel is bound to proceed at night at a moderate speed, or to alter his course so as to go well clear of the danger zone.

Article 11.

The vessels defined by Article 2 shall have on board a Morse signalling lamp of sufficient range.

The use of Morse signals is regulated by the Code appearing in Article III, as well as by Article IV of the Regulations annexed hereto.

ARTICLE 12.

The use of the international distress signals for any other purpose than that of signals of distress is prohibited on every vessel.

The use of private signals which are liable to be mistaken for the international distress signals is prohibited on every vessel.

ARTICLE 13.

The selection of the routes across the North Atlantic in both directions is left to the responsibility of the steamship companies. Nevertheless the High Contracting Parties undertake to impose on these companies the obligation to give public notice of the regular routes which they propose their vessels should follow, and of any changes which they make in them.

The High Contracting Parties undertake, further, to use their influence to induce the owners of all vessels crossing the Atlantic to follow as far as possible the routes adopted by the principal companies.

ARTICLE 14.

The High Contracting Parties undertake to use all diligence to obtain from the Governments which are not parties to this Convention their agreement to the revision of the International Regulations for Preventing Collisions at Sea as indicated below.

(*A*) The Regulations shall be completed or revised in regard to the following points:

(1) The second white light.

(2) The stern light.

(3) A day signal for motor vessels.

(4) A sound signal for a vessel towed.

(5) The prohibition of signals similar to distress signals.

(*B*) Articles 2, 10, 14, 15, 31 of the said Regulations shall be amended in accordance with the following provisions:

Article 2. The second white mast-head light to be compulsory.

Article 10. A permanent fixed stern light to be compulsory.

Article 14. A special day signal to be compulsory for motor vessels.

Article 15. A special sound signal to be established for use by a vessel in tow, or if the tow is composed of several vessels by the last vessel of the tow.

Article 31. Article 31 to be modified in the following manner: Add to the lists of both day and night signals the international radiotelegraph distress signal.

ARTICLE 15.

The Governments of the High Contracting Parties undertake to maintain, or, if it is necessary, to adopt, measures for the purpose of insuring that, from the point of view of safety of life at sea, the vessels defined in Article 2 shall be sufficiently and efficiently manned.

Chapter IV.—Construction.

Article 16.

NEW VESSELS AND EXISTING VESSELS.

For the application of the Articles contained in this Chapter and in the corresponding part of the Regulations annexed hereto, the vessels defined in Article 2 are divided into "new vessels" and "existing vessels."

New vessels are those the keel of which is laid after the 1st July, 1915. The following Articles of this Chapter, namely, Articles 17 to 30, are applicable to them in full.

Other vessels are considered as existing vessels. Existing arrangements on each of these vessels shall be considered by the Administration of the State to which the vessel belongs, with a view to improvements providing increased safety where practicable and reasonable.

Article 17.

SUBDIVISION OF VESSELS.

Vessels shall be as efficiently subdivided as is possible having regard to the nature of the service for which they are intended. The minimum requirements respecting subdivision and arrangements affecting subdivision are given in the following articles and in the Regulations annexed to this Convention.

The degree of safety provided for by these minimum requirements varies in a regular and continuous manner with the length of the vessel and with a certain "criterion of service." The requirements of the annexed Regulations are such that the highest degree of safety corresponds with the vessels of greatest length primarily engaged in the transportation of passengers.

Articles V to IX of the annexed Regulations indicate the method to be followed in order to determine the permissible length of compartments on the basis of the floodable length; prescribe a limit to the length of compartments; and fix the conditions governing certain special cases.

When the watertight subdivision of a vessel is such as to provide for a degree of safety greater than that provided by the rules prescribed by this Convention, the Administration of the State to which the vessel belongs shall, if so requested by the owner, record this fact on the Safety Certificate of the vessel to the extent and in the manner provided in Article X of the annexed Regulations.

Article 18.

PEAK AND MACHINERY SPACE BULKHEADS.

Vessels shall be fitted with forward and after peak bulkheads and bulkheads at the extremities of the machinery space in accordance with the provisions of Article XI of the annexed Regulations.

Article 19.

FIREPROOF BULKHEADS.

With a view to retarding the spread of fire, vessels shall be fitted with fireproof bulkheads in accordance with the provisions of Article XII of the annexed Regulations.

Article 20.

EXITS FROM WATERTIGHT COMPARTMENTS.

The conditions under which means of escape from the various watertight compartpartments shall be provided are indicated in Article XIII of the annexed Regulations.

Article 21.

CONSTRUCTION AND TESTS OF WATERTIGHT BULKHEADS.

In order to insure their strength and watertightness, watertight bulkheads shall be constructed and tested in accordance with the provisions of Article XIV of the annexed Regulations.

Article 22.

OPENINGS IN WATERTIGHT BULKHEADS.

The number of openings in watertight bulkheads shall be reduced to the minimum compatible with the design and proper working of the vessel; satisfactory means shall be provided for closing these openings. Articles XV and XVII of the annexed Regulations indicate the conditions governing the number of openings, the character and use of the means of closing with which these openings shall be provided, and the tests to which watertight doors shall be subjected.

Article 23.

OPENINGS IN VESSEL'S SIDE.

Side scuttles and other openings in the side of the vessel and the inboard openings of discharges through the shell shall be provided with means of closing them, and shall be arranged in such manner as to prevent so far as possible the accidental admission of water into the vessel. Articles XVI and XVII of the annexed Regulations indicate the conditions under which openings may be made in the vessel's side, the means which shall be provided for closing these openings, and the requirements as to operating the closing appliances.

Article 24.

CONSTRUCTION AND TESTS OF WATERTIGHT DECKS, ETC.

In order to insure their strength and watertightness, watertight decks, trunks, and ventilators shall be constructed and tested in accordance with the provisions of Article XVIII of the annexed Regulations.

Article 25.

PERIODICAL OPERATION AND INSPECTION OF WATERTIGHT DOORS, ETC.

The conditions under which inspections of watertight doors, etc., and drills for their operation, shall be made periodically during a voyage, are indicated in Article XIX of the annexed Regulations.

Article 26.

ENTRIES IN THE OFFICIAL LOG BOOK.

A record of the closing and opening of watertight doors, etc., and of all inspections and drills, shall be entered in the official log book as required by Article XX of the annexed Regulations.

Article 27.

DOUBLE BOTTOMS.

The conditions under which a double bottom shall be fitted in vessels of different lengths, and in particular the minimum extent of the double bottom longitudinally and transversely, are indicated in Article XXI of the annexed Regulations.

Article 28.

GOING ASTERN AND AUXILIARY STEERING APPARATUS.

Vessels shall comply, as regards their power of going astern and the fitting of auxiliary steering apparatus, with the provisions of Articles XXII and XXIII of the annexed Regulations.

Article 29.

INITIAL AND SUBSEQUENT SURVEYS OF VESSELS.

The general principles which shall govern the survey of the vessels defined in Article 2, whether new or existing, as regards hull, main and auxiliary boilers and machinery, and equipments, are stated in Articles XXIV to XXVI of the annexed Regulations. The Government of each of the High Contracting Parties undertakes—

(1) To draw up detailed regulations in accordance with these general principles, or to bring its existing regulations into agreement with these principles;

(2) To communicate these regulations to each of the other contracting States; and

(3) To secure that these regulations shall be enforced.

The detailed regulations referred to in the preceding paragraphs shall be in all respects such as to secure that, from the point of view of safety of life, the vessel is fit for the service for which it is intended.

Article 30.

QUESTIONS FOR FURTHER STUDY AND AGREEMENT—EXCHANGE OF INFORMATION.

The High Contracting Parties undertake to cause the study of the criterion of service referred to in Article 17 to be pressed forward, and to communicate to each other the results of that study.

The British Government is invited to undertake the duty of circulating this information, and, as soon as a definite result is attainable, of endeavoring to secure, through the diplomatic channel, the acceptance by the contracting States of the criterion. Upon its acceptance by each of the contracting States, as from a date and subject to the conditions to be agreed upon, such criterion shall have effect as if it were prescribed in the Convention.

The above procedure shall also be applied to the following items:

(1) The fitting of longitudinal watertight bulkheads, double skins and watertight decks and flats, and the question whether there may be allowed any increase in the length of transverse watertight compartments in way of which such longitudinal subdivision is fitted, and, if so, to what extent;

(2) The method of subdivision for obtaining the highest practicable degree of safety to be applied to vessels of shorter lengths than those covered by Article VIII of the annexed Regulations; and

(3) The results of experiments in regard to the proper margin of resistance above the pressure which watertight bulkheads are required to be capable of supporting, as referred to in Article XIV of the annexed Regulations.

The contracting States undertake to exchange all information as freely as possible in regard to the application of the rules of this Convention in matters relating to safety of construction. They shall communicate to each other the methods or rules which they adopt; information concerning any new fittings or appliances which they sanction; the decisions which they make in regard to points of principle not covered by the foregoing articles and the corresponding portion of the annexed Regulations; and the final results of their further studies in matters not definitely determined.

Chapter V.—Radiotelegraphy.

Article 31.

All merchant vessels belonging to any of the Contracting States, whether they are propelled by machinery or by sails, and whether they carry passengers or not, shall, when engaged on the voyages specified in Article 2, be fitted with a radiotelegraph installation, if they have on board 50 or more persons in all.

Advantage may not be taken of the provisions of Articles 2 and 3 of this Convention to exempt a vessel from the requirements of this chapter.

Article 32.

Vessels on which the number of persons on board is exceptionally and temporarily increased up to or beyond 50 as the result of force majeure, or because the master is under the necessity of increasing the number of his crew to fill the places of those who are ill, or is obliged to carry shipwrecked or other persons, are exempted from the above obligation.

Moreover, the Governments of each of the Contracting States, if they consider that the route and the conditions of the voyage are such as to render a radiotelegraph installation unreasonable or unnecessary, may exempt from the above requirement the following vessels:

(1) Vessels which in the course of their voyage do not go more than 150 sea miles from the nearest coast.

(2) Vessels on which the number of persons on board is exceptionally or temporarily increased up to or beyond 50 by the carriage of cargo hands for a part of the voyage, provided that the said vessels are not going from one continent to another, and that, during that part of their voyage, they remain within the limits of latitude 30° N. and 30° S.

(3) Sailing vessels of primitive build, such as dhows, junks, etc., if it is practically impossible to install a radiotelegraph apparatus.

Article 33.

Vessels which, in accordance with Article31 above, are required to be fitted with a radiotelegraph installation are divided, for the purpose of radiotelegraph service, into three classes, in accordance with the classification established for ship stations in Article XIII (*b*) of the Regulations annexed to the Radiotelegraph Convention, signed in London on the 5th July, 1912, viz.:

First Class.—Vessels having a continuous service.

There shall be placed in the First Class vessels which are intended to carry 25 or more passengers—

(1) If they have an average speed in service of 15 knots or more.

(2) If they have average speed in service of more than 13 knots, but only subject to the twofold condition that they have on board 200 persons or more (passengers and crew), and that, in the course of their voyage, they go a distance of more than 500 sea miles between any two consecutive ports. Nevertheless these vessels may be placed in the Second Class on condition that they have a continuous watch.

Second Class.—Vessels having a service of limited duration.

There shall be placed in the Second Class all vessels which are intended to carry 25 or more passengers, if they are not, for other reasons, placed in the First Class.

Vessels placed in the Second Class must, during navigation, maintain a continuous watch for at least 7 hours a day, and a watch of 10 minutes at the beginning of every other hour.

Third Class.—Vessels which have no fixed periods of service.

All vessels which are placed neither in the First nor in the Second Class shall be placed in the Third Class.

The owner of a vessel placed in the Second or in the Third Class has the right to require that, if the vessel complies with all the requirements for a superior class, a statement to the effect that it belongs to that superior class shall be inserted in the Safety Certificate.

Article 34.

Vessels which are required by Article 31 above to be fitted with a radiotelegraph installation shall be required, by the Governments of the countries to which they belong, to maintain a continuous watch during navigation as soon as the said Governments consider that it will be of service for the purpose of safety of life at sea.

Meanwhile, the High Contracting Parties undertake to require, from the date of the ratification of the present Convention subject to the delays specified below, a continuous watch on the following vessels:

(1) Vessels whose average speed in service exceeds 13 knots, which have on board 200 persons or more, and which, in the course of their voyage, go a distance of more than 500 sea miles between two consecutive ports, when these vessels are placed in the Second Class.

(2) Vessels in the Second Class, for the whole of the time during which they are more than 500 sea miles from the nearest coast.

(3) Other vessels specified in Article 31, when they are engaged in the Trans-Atlantic trade, or when they are engaged in other trades if their route takes them more than 1,000 sea miles from the nearest coast.

Vessels connected with all kinds of fishing business including whaling, which are required to be fitted with a radiotelegraph installation, shall not be required to maintain a continuous watch.

The continuous watch may be kept by one or more operators, holding certificates in accordance with Article X of the Regulations annexed to the International Radiotelegraph Convention, 1912, together, if necessary, with one or more certificated watchers. Nevertheless, if an efficient automatic calling apparatus is invented, the continuous watch may be main-

tained by this means by agreement between the Governments of the High Contracting Parties.

By "certificated watcher" is meant any person holding a certificate issued under the authority of the Administration concerned. To obtain this certificate, the applicant must prove that he is capable of receiving and understanding the radiotelegraph distress signal and the safety signal described in the Regulations annexed hereto.

The High Contracting Parties undertake to take steps to insure that the certificated watchers observe the secrecy of correspondence.

ARTICLE 35.

The radiotelegraph installations required by Article 31 above shall be capable of transmitting clearly perceptible signals from ship to ship over a range of at least 100 sea miles by day under normal conditions and circumstances.

Every vessel which is required, in conformity with the provisions of Article 31 above, to be fitted with a radiotelegraph installation, shall, whatever be the class in which it is placed, be provided in accordance with Article XI of the Regulations annexed to the International Radiotelegraph Convention, 1912, with an emergency installation, every part of which is placed in a position of the greatest possible safety to be determined by the Government of the country to which the vessel belongs.

In all cases the emergency installation must be placed, in its entirety, in the upper part of the vessel, as high as practically possible.

The emergency installation includes, as provided by Article XI of the Regulations annexed to the International Radiotelegraph Convention, 1912, an independent source of energy capable of being put into operation rapidly and of working for at least six hours with a minimum range of 80 sea miles for vessels in the First Class and 50 sea miles for vessels in the two other Classes.

If the normal installation, which in accordance with this Article has a range of at least 100 sea miles, satisfies all the conditions prescribed above, an emergency installation is not required.

The license provided for in Article IX of the Regulations annexed to the International Radiotelegraph Convention, 1912, may not be issued unless the installation complies both with the provisions of that Convention, and also with the provisions of this Convention.

ARTICLE 36.

The matters governed by the International Radiotelegraph Convention, 1912, and the Regulations annexed thereto, and in particular the radiotelegraph installations on ships, the transmission of messages, and the certificates of the operators, remain and will continue subject to the provisions—

(1) Of that Convention and the Regulations annexed thereto, or of any other instruments which may in the future be substituted therefor;

(2) Of this Convention, in regard to all the points in which it supplements the aforementioned documents.

ARTICLE 37.

Every master of a vessel who receives a call for assistance from a vessel in distress is bound to proceed to the assistance of the persons in distress.

Every master of a vessel in distress has the right to requisition from among the vessels which answer his call for assistance the vessel or vessels which he considers best able to render him assistance, but he must exercise this right only after consultation, so far as may be possible, with the masters of those vessels. Such vessels are then bound to comply immediately with the requisition by proceeding with all speed to the assistance of the persons in distress.

The masters of the vessels which are required to render assistance are released from this obligation as soon as the master or masters requisitioned have made known that they will comply with the requisition, or as soon as the master of one of the vessels which has reached the scene of the casualty has made known to them that their assistance is no longer necessary.

If the master of a vessel is unable, or considers it unreasonable or unnecessary, in the special circumstances of the case, to go to the assistance of the vessel in distress, he must immediately inform the master of the vessel in distress accordingly. Moreover he must enter in his log book the reasons justifying his action.

The above provisions do not prejudice the International Convention for the unification of certain rules with respect to Assistance and Salvage at Sea, signed at Brussels on the 23rd September, 1910, and, in particular, the obligation to render assistance laid down in Article 11 of that Convention.

Article 38.

The High Contracting Parties undertake to take all steps necessary for giving effect to the provisions of this Chapter with the least possible delay. Nevertheless, they may allow—

A delay not exceeding one year, from the date of the ratification of this Convention, for the provision and training of operators and for the installation of the apparatus on vessels placed in the First and Second Classes.

A delay not exceeding two years, from the date of the ratification of this Convention, for the provision and training of the operators and watchers on the vessels in the Third Class, for the installation of the apparatus on vessels in the Third Class, and for the establishment of a continuous watch on vessels placed in the Second and Third Classes.

Chapter VI.—Life-Saving Appliances and Fire Protection.

Article 39.

NEW VESSELS AND EXISTING VESSELS.

For the application of the Articles contained in this chapter and of the corresponding part of the Regulations annexed hereto the vessels defined in Article 2 are divided into *new vessels* and *existing vessels.*

New vessels are those of which the keel is laid after the 31st December. 1914.

Other vessels are considered as *existing vessels.*

Article 40.

FUNDAMENTAL PRINCIPLE.

At no moment of its voyage may a vessel have on board a total number of persons greater than that for whom accommodation is provided in the lifeboats and the pontoon life rafts on board.

The number and arrangement of the boats, and (where they are allowed) of the pontoon rafts, on a vessel depend upon the total number of persons which the vessel is intended to carry; provided that there shall not be required on any voyage a total capacity in boats, and (where they are allowed) pontoon rafts, greater than that necessary to accommodate all the persons on board.

Article 41.

STANDARD TYPES OF BOATS—PONTOON RAFTS.

All the lifeboats allowed for a vessel shall comply with the conditions fixed by this Convention and Articles XXVII to XXXII of the Regulations annexed hereto; the same articles describe the standard types which are divided into two classes.

The conditions required for the pontoon rafts are given in Article XXXIII of the same Regulations.

Article 42.

STRENGTH OF BOATS.

Each boat must be of sufficient strength to enable it to be safely lowered into the water when loaded with its full complement of persons and equipment.

Article 43.

ALTERNATIVE TYPES OF BOATS AND RAFTS.

Any type of boat may be accepted as equivalent to a boat of one of the prescribed classes and any type of raft as equivalent to an approved pontoon raft, if the Administrations concerned are satisfied by suitable trials that it is as effective as the standard types of the class in question, or as the approved type of pontoon raft, as the case may be.

The Government of the High Contracting Party which accepts a new type of boat or raft will communicate to the Governments of the other Contracting Parties particulars of the trials made. It will also inform them of the class in which a new type of boat has been placed.

Article 44.

EMBARKATION OF THE PASSENGERS IN THE BOATS AND RAFTS.

Suitable arrangements shall be made for embarking the passengers in the boats.

In vessels which carry rafts there shall be a number of rope ladders always available for use in embarking the persons on to the rafts.

Article 45.

CAPACITY OF BOATS AND PONTOON RAFTS.

The number of persons that a boat of one of the standard types or an approved pontoon raft can accommodate is determined by the methods indicated in Articles XXXIV to XXXIX, inclusive, of the Regulations annexed hereto.

Article 46.

EQUIPMENT OF BOATS AND PONTOON RAFTS.

Article XL of the annexed Regulations prescribes the equipment for boats and pontoon rafts. All loose equipment must be securely attached to the boat or pontoon raft to which it belongs.

Article 47.

STOWAGE OF BOATS—NUMBER OF DAVITS.

The arrangements to be made for the stowage of the boats and in particular the extent to which pontoon rafts may be accepted are specified in Articles XLI, XLII, and XLIII of the annexed Regulations.

The minimum number of sets of davits is fixed in relation to the length of the vessel; provided that a number of sets of davits greater than the number of boats necessary for the accommodation of all the persons on board may not be required.

Article 48.

HANDLING OF THE BOATS AND RAFTS.

All the boats and rafts must be stowed in such a way that they can be launched in the shortest possible time and that, even under unfavorable conditions of list and trim from the point of view of the handling of the boats and rafts, it may be possible to embark in them as large a number of persons as possible.

The arrangements must be such that it may be possible to launch on either side of the vessel as large a number of boats and rafts as possible.

Supplementary instructions are given in Article XLIV of the annexed Regulations.

Article 49.

STRENGTH AND OPERATION OF THE DAVITS.

The davits shall be of such strength that the boats can be lowered with their full complement of persons and equipment, the vessel being assumed to have a list of 15 degrees.

The davits must be fitted with a gear of sufficient power to insure that the boat can be turned out against the maximum list under which the lowering of the boats is possible on the vessel in question.

Article 50.

OTHER APPLIANCES EQUIVALENT TO DAVITS.

Any appliance may be accepted in lieu of davits or sets of davits if the Administration concerned is satisfied, after proper trials, that the appliance in question is as effective as davits for placing the boats in the water.

The Government of the High Contracting Party which accepts a new type of appliance shall communicate to the other Contracting Parties particulars of the appliance with details of the trials made.

Article 51.

LIFE JACKETS AND LIFE BUOYS.

(1) A life jacket of an approved type, or other appliance of equal buoyancy and capable of being fitted on the body, shall be carried for every person on board, and, in addition, a sufficient number of life jackets, or other equivalent appliances, suitable for children.

(2) Article XLV of the annexed Regulations fixes in accordance with the length of the vessel the number of life buoys of an approved type to be carried, and also the conditions with which life jackets and life buoys must comply, and in accordance with which they must be stowed.

Article 52.

EXISTING VESSELS.

The Government of each of the High Contracting Parties undertakes to apply to existing vessels, as soon as possible and not later than the 1st July, 1915, all the provisions of the preceding Articles of the present Chapter, namely, Articles 40 to 51 inclusive, requiring, in the first place, accommodation for all the persons on board in boats and rafts; provided that, in cases where the strict application of these principles would not be practicable or reasonable, the Government of each of the High Contracting Parties has the right to allow the exemptions specified in Article XLVI of the Regulations annexed hereto.

Article 53.

MEANS OF INGRESS AND EGRESS—EMERGENCY LIGHTING.

(1) Proper arrangements shall be made for ingress to and egress from the different compartments, decks, etc.

(2) Provision shall be made for an electric or other system of lighting, sufficient for all requirements of safety, in the different parts of both new and existing vessels, and particularly upon the decks on which the lifeboats are stowed. On new vessels there must be a self-contained source capable of supplying, when necessary, this safety lighting system, and placed in the upper parts of the vessel, as high as practically possible.

(3) The exit from every compartment must always be lighted by an emergency lamp, which shall be kept locked, and which shall be independent of the ordinary lighting of the ship. These emergency lamps may be supplied from the independent installation referred to in the preceding paragraph, if an independent circuit is employed for this purpose and if this installation works concurrently with the ordinary lighting of the vessel.

Article 54.

CERTIFICATED LIFEBOAT MEN—MANNING OF THE BOATS.

There must be, for each boat or raft required, a minimum number of certificated lifeboat men. The minimum total number of certificated lifeboat men is determined by the provisions of Article XLVII of the annexed Regulations.

The allocation of the certificated lifeboat men to each boat and raft remains within the discretion of the master, according to the circumstances.

By "certificated lifeboat man" is meant any member of the crew who holds a certificate of efficiency issued under the authority of the Administration concerned, in accordance with the conditions laid down in the aforementioned Article of the annexed Regulations.

Article XLVIII of the Regulations deals with the manning of the boats.

Article 55.

FIRE PROTECTION.

(1) The carriage, either as cargo or ballast, of goods which by reason of their nature, quantity, or mode of stowage, are, either singly or collectively, likely to endanger the lives of the passengers or the safety of the vessel, is forbidden.

This provision does not apply to the vessel's distress signals, nor to the carriage of naval or military stores for the public service of the State under authorized conditions.

(2) The Government of each High Contracting Party shall, from time to time by official notice, determine what goods are to be considered dangerous goods, and shall indicate the precautions which must be taken in the packing and stowage thereof.

(3) Article XLIX of the annexed Regulations indicates the arrangements to be made for the detection and extinction of fire.

Article 56.

MUSTER ROLL AND DRILLS.

Special duties for the event of an emergency shall be allotted to each member of the crew.

The muster list shows all these special duties, and indicates, in particular, the station to which each man must go, and the duties that he has to perform.

Before the vessel sails, the muster list shall be drawn up and exhibited, and the proper authority shall be satisfied that the muster list has been prepared for the vessel. It shall be posted in several parts of the vessel, and in particular in the crew's quarters.

Articles L and LI of the annexed Regulations indicate the conditions under which musters of the crew and drills shall take place.

Chapter VII.—Safety Certificates.

Article 57.

A certificate, called a "Safety Certificate," shall be issued, after inspection and survey, to every vessel which complies in an efficient manner with the requirements of the Convention.

The inspection and survey of vessels, so far as regards the enforcement of the provisions of this Convention and the annexed Regulations, shall be carried out by officers of the State to which the vessel belongs; provided always that the Government of each State may entrust the inspection and survey of vessels of its own country either to surveyors nominated by it for this purpose or to organizations recognized by it. In every case the Government concerned fully guarantees the completeness and efficiency of the inspection and survey.

The Safety Certificate shall be issued either by the officers of the State to which the

vessel belongs, or by any other person duly authorized by that State. In either case the State to which the vessel belongs assumes full responsibility for the certificate.

ARTICLE 58.

The Safety Certificate shall be drawn up in the official language or languages of the State by which it is issued.

The form of the certificate shall be that of the model given in Article LII of the Regulations annexed hereto. The arrangement of the printed part of this standard certificate shall be exactly reproduced, and the particulars inserted by hand shall be inserted in Roman characters and Arabic figures.

The High Contracting parties undertake to communicate one to another a sufficient number of specimens of their Safety Certificates for the information of their officers. This exchange shall be made, so far as possible, before the 1st April, 1915.

ARTICLE 59.

The Safety Certificate shall not be issued for a period of more than 12 months.

If the vessel is not in a port of the State to which it belongs at the time when the period of the validity of the Safety Certificate expires a duly authorized officer of this State may extend this period; but such an extension shall be granted only for the purpose of allowing the vessel to complete its return voyage to its own country, and then only in cases in which it appears proper and reasonable so to do.

The extension cannot have effect for more than five months, and the vessel shall not thereby be entitled to leave its own country again without having obtained a new certificate.

ARTICLE 60.

The Safety Certificate issued under the authority of a Contracting State shall be accepted by the Governments of the other Contracting States for all purposes covered by this Convention. It shall be regarded by the Governments of the other Contracting States as having the same force as the certificates issued by them to their own vessels.

ARTICLE 61.

Every vessel holding a Safety Certificate issued by the officers of the Contracting State to which it belongs, or by persons duly authorized by that State, is subject in the ports of the other Contracting States to control by officers duly authorized by their Governments in so far as this control is directed towards verifying that there is on board a valid Safety Certificate, and, if necessary, that the conditions of the vessel's seaworthiness correspond substantially with the particulars of that certificate; that is to say, so that the vessel can proceed to sea without danger to the passengers and the crew.

ARTICLE 62.

The privileges of the Convention may not be claimed in favor of any vessel unless it holds a proper valid Safety Certificate.

Article 63.

If, in the course of a particular voyage, the vessel has on board a number of passengers less than the maximum number indicated in the Safety Certificate, and is, in consequence, in accordance with the provisions of this Convention free to carry a smaller number of lifeboats and other life-saving appliances than that stated in the aforementioned Certificate, a memorandum may be issued by the officers or other authorized persons referred to in Articles 57 (paragraph 3) and 59 above.

This memorandum shall state that in the circumstances there is no infringement of the provisions of the Convention. It shall be annexed to the Safety Certificate and shall be substituted for it in so far as the life-saving appliances are concerned. It shall be valid only for the particular voyage in regard to which it is issued.

Chapter VIII.—General.

Article 64.

The Governments of the High Contracting Parties undertake to communicate mutually, in addition to the documents which, in this Convention, are the subject of special provisions to that effect, all information which they possess affecting safety of life on those of their vessels which are subject to the rules of this Convention, provided always that such information is not of a confidential nature.

They will communicate to each other in particular—

1. The text of Laws, Decrees and Regulations which shall have been promulgated on the various matters within the scope of the Convention.

2. The description of the characteristics of new appliances approved in administering the rules of the Convention.

3. All official reports, or official summaries of reports, in so far as they show the results of the provisions of this Convention.

Until other arrangements may be made, the British Government is invited to serve as intermediary for collecting all this information and for bringing it to the knowledge of the Governments of the Contracting Parties.

Article 65.

The High Contracting Parties undertake to take, or to propose to their respective legislatures, the measures necessary for the repression of infractions of the requirements imposed by this Convention.

The High Contracting Parties will communicate mutually, as soon as possible, the laws and regulations which are issued for this purpose.

Article 66.

The High Contracting Parties which intend the Convention to apply to the whole of their Colonies, Possessions and Protectorates, or to one or to some of these countries, shall declare this intention either at the time of signing these presents or subsequently. To this effect they shall be able either to make a general declaration embracing the whole

of their Colonies, Possessions and Protectorates, or to enumerate by name the countries which they intend to come within the scope of the law of the Convention, or, alternatively, to enumerate by name those which they intend to be excepted.

This declaration, unless it be made at the time of signing this Convention, shall be made in writing to the Government of Great Britain, and communicated by the latter Government to all the Governments of the other States parties to the Convention.

The High Contracting Parties may also in the same way, provided that they comply with the provisions of Article 69 hereafter, denounce this Convention as regards their Colonies, Possessions or Protectorates or one or some of those countries.

ARTICLE 67.

The States which are not Parties to this Convention shall be allowed to accede thereto at their request. Their accession shall be notified through the diplomatic channel to the Government of Great Britain, and by the latter to the Governments of the other States parties to the Convention.

This accession will carry the full acceptance of all the obligations imposed by this Convention and the full right to all the privileges specified therein. It will have full and complete effect two months after the date on which notification of the accession is sent by the Government of Great Britian to all the other Governments of the States which are parties to the Convention, unless a later date had been proposed by the acceding State.

The Governments of the States which accede to the present Convention shall annex to their declaration of accession the schedule provided for by Article 3 of this Convention. This schedule shall be added to those already deposited by the other Governments. The British Government shall transmit a copy thereof to the other Governments.

ARTICLE 68.

The treaties, conventions and arrangements concluded prior to this Convention shall continue to have full and complete effect, as regards—

(1) Vessels excepted from the Convention;

(2) Vessels to which it applies, in respect of subjects for which the Convention has not expressly provided.

It is understood that, the subject of this Convention being safety of life at sea, questions relating to the well-being and health of passengers, and in particular of emigrants, as well as other matters relative to their transport, continue subject to the legislation of the different States.

ARTICLE 69.

This Convention shall come into force on the 1st July, 1915, and shall remain in force without any prescribed limit of time. Nevertheless, each High Contracting Party may denounce the Convention at any time after an interval of five years from the date on which the Convention comes into force in that State.

This denunciation shall be notified through the diplomatic channel to the Government of Great Britain and by the latter to the Governments of the other Contracting Parties. It shall take effect 12 months after the day on which the notification is received by the Government of Great Britain.

A denunciation shall only affect the State which makes it, the Convention remaining fully and completely operative as regards all the other States which have ratified it, or which have acceded thereto or which thereafter accede thereto.

ARTICLE 70.

This Convention with the Regulations annexed thereto shall be drawn up in a single copy which shall be deposited in the archives of the Government of Great Britain. A true and certified copy shall be delivered by the latter to each of the Governments of the High Contracting Parties.

ARTICLE 71.

This Convention shall be ratified and the instruments of ratification accompanied by the schedules specified in Article 3 shall be deposited at London not later than the 31st December, 1914. The British Government shall give notice of the ratifications and shall furnish a copy of each schedule to the Governments of the other Contracting Parties.

Notwithstanding failure to ratify on the part of a High Contracting Party, the Convention shall continue to have full and complete effect as regards the Contracting Parties which ratify it.

ARTICLE 72.

To render ratification easier for a Contracting State which, prior to the date of signature of this Convention, has laid down the requirements in regard to any matter within the scope of this Convention, it is agreed that no vessel which has complied with those requirements before the 1st July, 1915, may avail itself of the periods of grace allowed by the Convention, in order to cease to comply with those requirements.

ARTICLE 73.

Where this Convention provides that a measure may be taken after agreement between all or some of the Contracting States, the Government of His Britannic Majesty is invited to approach the said States with a view to ascertaining whether they accept the proposals made by one of these States for effecting such a measure. The Government of His Britannic Majesty will make known to the Contracting States the result of the inquiries which it thus makes.

A State from which observations on the proposals in question do not reach his Britannic Majesty's Government within six months from the communication of these proposals, will be presumed to acquiesce therein.

ARTICLE 74.

This Convention may be modified at subsequent Conferences, of which the first shall be held, if necessary, in 1920. The place and time of these Conferences shall be fixed by common consent by the Governments of the High Contracting Parties.

The Governments may, through the diplomatic channel, introduce into this Convention, by common consent and at any time, improvements which may be judged useful or necessary.

In witness whereof the Plenipotentiaries have signed hereafter.
Done at London, 20th January, 1914.

VON KOERNER. RIESS.
SEELIGER. PAGEL.
SCHÜTT. SCHRADER.
BEHM.

G. FRANCKENSTEIN. DUNAY.
SCHRECKENTHAL.

E. A. PIERRARD. LOUIS FRANCK.
CH. H. LE JEUNE.

EMIL KROGH. V. TOPSÖE-JENSEN.

RAFAEL BAUSÁ.

JOSHUA W. ALEXANDER. GEORGE F. COOPER.
JAS. HAMILTON LEWIS. HOMER L. FERGUSON.
EUGENE T. CHAMBERLAIN. ALFRED GILBERT SMITH.
ELLSWORTH P. BERTHOLF. WM. H. G. BULLARD.
WASHINGTON LEE CAPPS. GEORGE UHLER.

GUERNIER.

MERSEY. ALFRED H. F. YOUNG.
ERNEST G. MOGGRIDGE. C. HIPWOOD.
A. DENNY. W. DAVID ARCHER.
NORMAN HILL. R. MUIRHEAD COLLINS.
J. H. BILES. ALEXANDER JOHNSTON.
H. ACTON BLAKE. THOS. MACKENZIE.

CARLO BRUNO. GUSTAVO TOSTI.
VITTORIO RIPA DI MEANA.

HARALD PEDERSEN.
J. BRUHN. } *ad referendum*
JENS EVANG.

J. V. WIERDSMA. WILMINK.
H. S. J. MAAS. J. W. G. COOPS.
A. D. MULLER.

N. DE ETTER.

A. O. OLSEN. NILS GUSTAF NILSSON.

REGULATIONS.

SAFETY OF NAVIGATION.

ARTICLE I.

CODE FOR THE TRANSMISSION BY RADIOTELEGRAPHY OF INFORMATION RELATING TO ICE, DERELICTS, AND WEATHER.

INSTRUCTIONS.

Transmission of information.—The transmission of information concerning ice and derelicts is obligatory. This information may be sent from ship to ship or to the Hydrographic Office, Washington, either in clear or by means of the abbreviations used in Part I of this Code.

The transmission of information relating to weather is optional. Part II of this Code may be used for this purpose, but may be modified at any time by the meteorological congresses.

Information required:

PART I.—ICE AND DERELICTS.

1. The kind of ice or derelict observed.
2. The position of ice or derelict when last determined.

PART II.—METEOROLOGICAL INFORMATION.

1. The direction and force of the wind.
2. The set and velocity of the current.
3. Weather or state of the sky at a fixed hour.
4. Height of barometer and air temperature.
5. Barometric tendency and sea-surface temperature.

Time to be adopted.—In all radiotelegrams relating to ice or derelicts the time shall be given in Greenwich mean time.

Address.—Reports, when sent to the Hydrographic Office, Washington, should be addressed "Hydrographic"; reports to the Meteorological Office, London, should be addressed "Meteorology."

Message.—1. When sending information about ice or derelicts alone, two groups of five figures each are used, preceded by the word "ice"; these groups may be repeated as often as necessary.

2. If meteorological information is to be sent in addition, a further four groups of five figures each are used, preceded by the word "weather." These groups are inserted at the end of the message after all the information relating to ice has been given.

N. B.—If the message contains the word "weather," all the code groups before that word give information relating to ice, and those after the word "weather" give meteorological information. If there is no word "weather" in the message, it only contains information about ice. (See examples of the two kinds of message given in this Article.)

Part I.

ICE AND DERELICTS.

Information respecting ice and derelicts is given by means of ten figures divided into two groups of five figures each. These groups are preceded by the word "ice."

Two figures .....The day of the month (*dd*), according to Code I.
One figure .....The time of observation (*T*), according to Code II.
One figure .....The kind of ice observed (*I*), according to Code III.
Three figures ....The latitude of the ice observed (*ppp*) to tenths of a degree (see table below).
Three figures ....The longitude of the ice observed (*p'p'p'*) to tenths of a degree (see table below).

The first group consists of *ddTIp*.
The second group consists of *ppp'p'p'*.

CODES.

Code I.—Day of the month.

The day of the month is given by two figures, of which the first may be zero: 01 to 31.

Code II.—Time of observation.

The time of observation is included between—

Greenwich mean time.

	Code No.
1 a.m. and 4 a.m.	1
4 a.m. and 7 a.m.	2
7 a.m. and 10 a.m.	3
10 a.m. and 1 p.m.	4
1 p.m. and 4 p.m.	5
4 p.m. and 7 p.m.	6
7 p.m. and 10 p.m.	7
10 p.m. and 1 a.m.	8

Code III.—Nature of ice or derelict observed.

0. No ice observed.
1. Single iceberg. Huge mass of floating ice.
2. Several icebergs.
3. Numerous icebergs.

4. Floeberg. Thick piece of salt-water ice like a small iceberg.

5. Field ice. Ice extending as far as the eye can reach, but through which it is possible to navigate.

6. Pack ice. Pieces of ice broken from berg or floe, partly closed together.

7. Land ice. Ice attached to the shore since the winter.

8. Derelict.

9. (Not allotted.)

Example: Message sent from ship to ship.

	First message.	Coded as—	Second message.	Coded as—	Third message.	Coded as—	Fourth message.	Coded as—
Date of observation.....	15	15	15	15	15	15	16	16
Time of observation	10-12	4	16-18	6	19-21	7	4-6	2
Nature of ice or derelict	Field.....	5	Numerous icebergs.	3	Derelict ...	8	Single iceberg.	1
Position of ice or derelict	Latitude, 45° 42′.	457	Latitude, 46° 5′.	461	Latitude, 46° 25′.	464	Latitude, 47° 19′.	473
	Longitude, 46° 11′.	462	Longitude, 44° 40′.	447	Longitude, 43° 58′.	440	Longitude, 40° 15′.	402

The code of the above message would thus be:

S.S. to S.S.

Ice, 15454, 57462 : 15634, 61447 : 15784, 64440 : 16214, 73402.

Part II.

METEOROLOGICAL INFORMATION.

Information respecting weather, etc., is given by four groups of five figures each. These groups are preceded by the word "weather."

First group (*DDPPP*).—The day of the month; two figures (*DD*), according to Code I.

The position of the ship when transmitting the message, indicated by three figures (*PPP*), representing the 1° square in which the ship is situated, according to Code IV and the numbered chart annexed to this Article.

Second group (*WWCCX*).—Wind direction and force, at 8 a.m. at the 75th meridian of west longitude; two figures (*WW*), according to Code V.

Set and velocity of current; two figures (*CC*), according to Code VI.

Weather or state of the sky at the same hour; one figure (*X*), according to Code VII.

Third group (*BBBAA*).—The barometric height to tenths of a millimeter, at 8 a.m. at the 75th meridian of west longitude; three figures (*BBB*), according to Code VIII.

Air temperature at the same hour; two figures (*AA*), according to Code IX.

Fourth group (*bbSSS*).—Barometric tendency, at 8 a.m. at the 75th meridian of west longitude; two figures (*bb*), according to Code X.

Sea-surface temperature at the same hour; three figures (*SSS*), according to Code XI.

CODES.

Code IV.—Position of vessel.

The chart annexed to this Article gives the numbers to be assigned to each 1° square in the North Atlantic. The position of the ship, when the meteorological data given in Part

II were observed, is indicated by the three figures representing the 1° square in which the ship is situated. For example, a position 51° 55′ N., 26° 49′ W. would be reported as 561.

Code V.—Wind direction (to 16 points) and wind force at 8 a.m. mean time at the 75th meridian of west longitude (WW).

	Wind force, Beaufort scale.	N. N. E.	N. E.	E. N. E.	E.	E. S. E.	S. E.	S. S. E.	S.	S. S. W.	S. W.	W. S. W.	W.	W. N. W.	N. W.	N. N. W.	N.
Calm	0	00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Light breeze	1, 2 or 3.	01	07	13	19	25	31	37	43	49	55	61	67	73	79	85	91
Moderate breeze ..	4 or 5 ..	02	08	14	20	26	32	38	44	50	56	62	68	74	80	86	92
Strong wind.....	6 or 7 ..	03	09	15	21	27	33	39	45	51	57	63	69	75	81	87	93
Gale force	8 or 9 ..	04	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
Storm force	10 or 11.	05	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
Hurricane	12	06	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96

N. B.—The wind direction is to be referred to true bearings.

Code VI.—Direction (to 16 points) and velocity of the current (CC).

Nautical miles per hour.	N. N. E.	N. E.	E. N. E.	E.	E. S. E.	S. E.	S. S. E.	S.	S. S. W.	S. W.	W. S. W.	W.	W. N. W.	N. W.	N. N. W.	N.
0.25	01	07	13	19	25	31	37	43	49	55	61	67	73	79	85	91
0.5	02	08	14	20	26	32	38	44	50	56	62	68	74	80	86	92
1	03	09	15	21	27	33	39	45	51	57	63	69	75	81	87	93
2	04	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
3	05	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
4	06	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
	00	No current.														
	99	No observation.														

N. B.—The current is to be referred to true bearings.

Code VII.—The state of the sky, at 8 a.m. mean time at the 75th meridian of west longitude.

0. Sky quite clear.
1. Sky quarter clouded.
2. Sky half clouded.
3. Sky three-quarters clouded.
4. Sky entirely overcast.
5. Rain falling.
6. Snow or hail falling.
7. Haze or mist.
8. Fog.
9. Thunderstorm.

Code VIII.—Height of barometer.

The reading of the mercury barometer is to be corrected for index error, and reduced to 0° C. and sea level. A table of corrections is given below.

The corrected reading is coded by omitting the first figure of the barometer reading in tenths of a millimeter; for example, 761.2 mm. is coded as 612.

A table for converting hundredths of an inch to tenths of a millimeter is given below.

Code IX.

Air temperature is coded in two figures according to the following table:

Degrees centigrade.	Degrees Fahrenheit.	Code No.	Degrees centigrade.	Degrees Fahrenheit.	Code No.	Degrees centigrade.	Degrees Fahrenheit.	Code No.	Degrees centigrade.	Degrees Fahrenheit.	Code No.
—15.0	5.0	00	— 2.5	27.5	25	10.0	50.0	50	22.5	72.5	75
—14.5	5.9	01	— 2.0	28.4	26	10.5	50.9	51	23.0	73.4	76
—14.0	6.8	02	— 1.5	29.3	27	11.0	51.8	52	23.5	74.3	77
—13.5	7.7	03	— 1.0	30.2	28	11.5	52.7	53	24.0	75.2	78
—13.0	8.6	04	— 0.5	31.1	29	12.0	53.6	54	24.5	76.1	79
—12.5	9.5	05	0.0	32.0	30	12.5	54.5	55	25.0	77.0	80
—12.0	10.4	06	0.5	32.9	31	13.0	55.4	56	25.5	77.9	81
—11.5	11.3	07	1.0	33.8	32	13.5	56.3	57	26.0	78.8	82
—11.0	12.2	08	1.5	34.7	33	14.0	57.2	58	26.5	79.7	83
—10.5	13.1	09	2.0	35.6	34	14.5	58.1	59	27.0	80.6	84
—10.0	14.0	10	2.5	36.5	35	15.0	59.0	60	27.5	81.5	85
— 9.5	14.9	11	3.0	37.4	36	15.5	59.9	61	28.0	82.4	86
— 9.0	15.8	12	3.5	38.3	37	16.0	60.8	62	28.5	83.3	87
— 8.5	16.7	13	4.0	39.2	38	16.5	61.7	63	29.0	84.2	88
— 8.0	17.6	14	4.5	40.1	39	17.0	62.6	64	29.5	85.1	89
— 7.5	18.5	15	5.0	41.0	40	17.5	63.5	65	30.0	86.0	90
— 7.0	19.4	16	5.5	41.9	41	18.0	64.4	66	30.5	86.9	91
— 6.5	20.3	17	6.0	42.8	42	18.5	65.3	67	31.0	87.8	92
— 6.0	21.2	18	6.5	43.7	43	19.0	66.2	68	31.5	88.7	93
— 5.5	22.1	19	7.0	44.6	44	19.5	67.1	69	32.0	89.6	94
— 5.0	23.0	20	7.5	45.5	45	20.0	68.0	70	32.5	90.5	95
— 4.5	23.9	21	8.0	46.4	46	20.5	68.9	71	33.0	91.4	96
— 4.0	24.8	22	8.5	47.3	47	21.0	69.8	72	33.5	92.3	97
— 3.5	25.7	23	9.0	48.2	48	21.5	70.7	73	34.0	93.2	98
— 3.0	26.6	24	9.5	49.1	49	22.0	71.6	74	34.5	94.1	99

Code X.—Barometric tendency.

By the "barometric tendency at a given hour" is meant the amount by which the barometric height has changed during the preceding three hours. It is to be expressed in millimeters. For example, the barometric tendency at 8 a.m. could be obtained by comparing

the reading taken at that hour, say 755.7 mm., with a reading taken at 5 a.m., say 759.3 mm. In this case the barometric tendency would be expressed by a fall of 3.6 millimeters. As a general rule the barometric tendency is to be determined from the trace of the barograph.

The barometric tendency is coded in two figures, according to the following table:

Rise in barometer.		Code No.	Rise in barometer.		Code No.	Fall in barometer.		Code No.	Fall in barometer.		Code No.
Millimeters.	Inches.		Millimeters.	Inches.		Millimeters.	Inches.		Millimeters.	Inches.	
0.0— 0.4	0.00—0.01	01	12.5—12.9	0.49—0.50	26	0.0— 0.4	0.00—0.01	51	12.5—12.9	0.49—0.50	76
0.5— 0.9	0.02—0.03	02	13.0—13.4	0.51—0.52	27	0.5— 0.9	0.02—0.03	52	13.0—13.4	0.51—0.52	77
1.0— 1.4	0.04—0.05	03	13.5—13.9	0.53—0.54	28	1.0— 1.4	0.04—0.05	53	13.5—13.9	0.53—0.54	78
1.5— 1.9	0.06—0.07	04	14.0—14.4	0.55—0.56	29	1.5— 1.9	0.06—0.07	54	14.0—14.4	0.55—0.56	79
2.0— 2.4	0.08—0.09	05	14.5—14.9	0.57—0.58	30	2.0— 2.4	0.08—0.09	55	14.5—14.9	0.57—0.58	80
2.5— 2.9	0.10—0.11	06	15.0—15.4	0.59—0.60	31	2.5— 2.9	0.10—0.11	56	15.0—15.4	0.59—0.60	81
3.0— 3.4	0.12—0.13	07	15.5—15.9	0.61—0.62	32	3.0— 3.4	0.12—0.13	57	15.5—15.9	0.61—0.62	82
3.5— 3.9	0.14—0.15	08	16.0—16.4	0.63—0.64	33	3.5— 3.9	0.14—0.15	58	16.0—16.4	0.63—0.64	83
4.0— 4.4	0.16—0.17	09	16.5—16.9	0.65—0.66	34	4.0— 4.4	0.16—0.17	59	16.5—16.9	0.65—0.66	84
4.5— 4.9	0.18—0.19	10	17.0—17.4	0.67—0.68	35	4.5— 4.9	0.18—0.19	60	17.0—17.4	0.67—0.68	85
5.0— 5.4	0.20—0.21	11	17.5—17.9	0.69—0.70	36	5.0— 5.4	0.20—0.21	61	17.5—17.9	0.69—0.70	86
5.5— 5.9	0.22—0.23	12	18.0—18.4	0.71—0.72	37	5.5— 5.9	0.22—0.23	62	18.0—18.4	0.71—0.72	87
6.0— 6.4	0.24—0.25	13	18.5—18.9	0.73—0.74	38	6.0— 6.4	0.24—0.25	63	18.5—18.9	0.73—0.74	88
6.5— 6.9	0.26—0.27	14	19.0—19.4	0.75—0.76	39	6.5— 6.9	0.26—0.27	64	19.0—19.4	0.75—0.76	89
7.0— 7.4	0.28—0.29	15	19.5—19.9	0.77—0.78	40	7.0— 7.4	0.28—0.29	65	19.5—19.9	0.77—0.78	90
7.5— 7.9	0.30—0.31	16	20.0—20.4	0.79—0.80	41	7.5— 7.9	0.30—0.31	66	20.0—20.4	0.79—0.80	91
8.0— 8.4	0.32—0.33	17	20.5—20.9	0.81—0.82	42	8.0— 8.4	0.32—0.33	67	20.5—20.9	0.81—0.82	92
8.5— 8.9	0.34—0.35	18	21.0—21.4	0.83—0.84	43	8.5— 8.9	0.34—0.35	68	21.0—21.4	0.83—0.84	93
9.0— 9.4	0.36—0.37	19	21.5—21.9	0.85—0.86	44	9.0— 9.4	0.36—0.37	69	21.5—21.9	0.85—0.86	94
9.5— 9.9	0.38—0.38	20	22.0—22.4	0.87—0.88	45	9.5— 9.9	0.38—0.38	70	22.0—22.4	0.87—0.88	95
10.0—10.4	0.39—0.40	21	22.5—22.9	0.89—0.90	46	10.0—10.4	0.39—0.40	71	22.5—22.9	0.89—0.90	96
10.5—10.9	0.41—0.42	22	23.0—23.4	0.91—0.92	47	10.5—10.9	0.41—0.42	72	23.0—23.4	0.91—0.92	97
11.0—11.4	0.43—0.44	23	23.5—23.9	0.93—0.94	48	11.0—11.4	0.43—0.44	73	23.5—23.9	0.93—0.94	98
11.5—11.9	0.45—0.46	24	24.0—24.4	0.95—0.96	49	11.5—11.9	0.45—0.46	74	The barometric tendency		99
12.0—12.4	0.47—0.48	25				12.0—12.4	0.47—0.48	75	cannot be reported.		

Code XI.—Sea-surface temperature.

Sea-surface temperature to tenths of a degree centigrade, is coded by three figures, or, when necessary, by two figures preceded by zero. If the temperature is negative, the first of these three figures is 5. For example:

— 2.2° C. is coded as 522.
+ 1.0° C. " 010.
+15.6° C. " 156.

Table of corrections for reducing barometric heights to 0° C. and to sea level.

[NOTE.—The barometric reading should first be corrected for index error. This error may be neglected if it is less than 0.3 mm. The + sign indicates that the correction is to be *added* to the barometric reading. The — sign indicates that the correction is to be *subtracted*.]

Temperature by the thermometer attached to the barometer.	—4° C. 24.8° F.	—2° C. 28.4° F.	0° C. 32° F.	+2° C. 35.6° F.	4° C. 39.2° F.	6° C. 42.8° F.	8° C. 46.4° C.	10° C. 50° F.	12° C. 53.6° F.	14° C. 57.2° F.	16° C. 60.8° F.	18° C. 64.4° F.	20° C. 68° F.	22° C. 71.6° F.	24° C. 75.2° F.	26° C. 78.8° F.	28° C. 82.4° F.
	Corrections to be made.																
Height of barometer cistern above sea level. *Meters.*	*Ft.*	*In.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
0..	0	0	+0.5	+0.3	0.0	—0.2	—0.5	—0.7	—1.0	—1.2	—1.5	—1.7	—2.0	—2.2	—2.5	—2.7	—3.0	—3.2	—3.5
1..	3	3	+0.6	0.4	+0.1	0.1	0.4	0.6	0.9	1.1	1.4	1.6	1.9	2.1	2.4	2.6	2.9	3.1	3.4
2..	6	7	+0.8	0.5	0.3	0.0	0.3	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.8	3.0	3.2
3..	9	10	+0.9	0.6	0.4	+0.1	0.1	0.4	0.6	0.9	1.1	1.4	1.6	1.9	2.1	2.4	2.6	2.9	3.1
4..	13	1	+1.0	0.8	0.5	0.2	0.0	0.3	0.5	0.8	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.8	3.0
5..	16	5	+1.2	0.9	0.7	0.4	+0.1	0.1	0.4	0.6	0.9	1.1	1.4	1.6	1.9	2.1	2.4	2.7	2.9
6..	19	8	+1.3	1.0	0.8	0.5	0.2	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.3	2.6	2.8
7..	22	0	+1.4	1.2	0.9	0.6	0.3	+0.1	0.1	0.4	0.6	0.9	1.1	1.4	1.6	1.9	2.2	2.4	2.7
8..	26	3	+1.5	1.3	1.0	0.7	0.5	0.2	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.1	2.3	2.6
9..	29	6	+1.7	1.4	1.2	0.8	0.6	0.3	+0.1	0.2	0.4	0.6	0.9	1.1	1.4	1.6	2.0	2.2	2.5
10..	32	10	+1.8	1.6	1.3	1.0	0.7	0.5	0.2	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.9	2.1	2.4
11..	36	1	+1.9	1.7	1.4	1.1	0.8	0.6	0.3	+0.1	0.2	0.4	0.7	0.9	1.2	1.4	1.8	2.0	2.2
12..	39	4	+2.0	1.8	1.5	1.2	1.0	0.7	0.5	0.2	0.0	0.3	0.5	0.8	1.1	1.3	1.6	1.9	2.1
13..	42	8	+2.2	1.9	1.7	1.3	1.1	0.8	0.6	0.3	+0.1	0.2	0.4	0.7	0.9	1.2	1.5	1.8	2.0
14..	45	11	+2.3	2.0	1.8	1.5	1.2	0.9	0.7	0.4	0.2	0.0	0.3	0.6	0.8	1.1	1.4	1.6	1.9
15..	49	3	+2.4	2.2	1.9	1.6	1.4	1.1	0.8	0.6	0.3	+0.1	0.2	0.5	0.7	1.0	1.3	1.5	1.8
16..	52	6	+2.5	2.3	2.0	1.7	1.5	1.2	0.9	0.7	0.4	0.2	0.1	0.4	0.6	0.9	1.2	1.4	1.6
17..	55	9	+2.6	2.4	2.1	1.9	1.6	1.3	1.1	0.8	0.6	0.3	+0.1	0.3	0.5	0.8	1.0	1.3	1.5
18..	59	1	+2.8	2.5	2.3	2.0	1.7	1.4	1.2	0.9	0.7	0.4	0.2	0.1	0.4	0.6	0.9	1.2	1.4
19..	62	4	+2.9	2.6	2.4	2.1	1.9	1.5	1.3	1.0	0.8	0.6	0.3	0.0	0.3	0.5	0.8	1.0	1.3
20..	65	7	+3.0	2.8	2.5	2.3	2.0	1.7	1.4	1.2	0.9	0.7	0.4	+0.1	0.2	0.4	0.7	0.9	1.2
21..	68	11	+3.1	2.9	2.6	2.4	2.1	1.8	1.5	1.3	1.0	0.8	0.5	0.2	0.1	0.3	0.6	0.8	1.1
22..	72	2	+3.3	3.0	2.8	2.5	2.2	1.9	1.7	1.4	1.2	0.9	0.6	0.3	+0.1	0.2	0.4	0.7	0.9
23..	75	6	+3.4	3.1	2.9	2.6	2.4	2.1	1.8	1.5	1.3	1.0	0.8	0.4	0.2	0.1	0.3	0.6	0.8

Table for converting barometric readings in inches into millimeters.

Inches and tenths.	Hundredths of an inch.									
	0	1.	2.	3.	4.	5.	6.	7.	8.	9.
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
27.0.....	685.8	686.0	686.3	686.6	686.8	687.1	687.3	687.6	687.8	688.1
.1.....	688.3	688.6	688.8	689.1	689.3	689.6	689.9	690.1	690.4	690.6
.2.....	690.9	691.1	691.4	691.6	691.9	692.1	692.4	692.7	692.9	693.2
.3.....	693.4	693.7	693.9	694.2	694.4	694.7	694.9	695.2	695.4	695.7
.4.....	696.0	696.2	696.5	696.7	697.0	697.2	697.5	697.7	697.9	698.2
.5.....	698.5	698.7	699.0	699.3	699.5	699.8	700.1	700.3	700.5	700.8
.6.....	701.0	701.3	701.5	701.8	702.0	702.3	702.6	702.8	703.1	703.3
.7.....	703.6	703.8	704.1	704.3	704.6	704.8	705.1	705.4	705.6	705.9
.8.....	706.1	706.4	706.6	706.9	707.1	707.4	707.6	707.9	708.1	708.4
.9.....	708.7	708.9	709.2	709.4	709.7	709.9	710.2	710.4	710.7	710.9
28.0.....	711.2	711.4	711.7	712.0	712.2	712.5	712.7	713.0	713.2	713.5
.1.....	713.7	714.0	714.2	714.5	714.7	715.0	715.3	715.5	715.8	716.0
.2.....	716.3	716.5	716.8	717.1	717.3	717.5	717.8	718.0	718.3	718.6
.3.....	718.8	719.1	719.3	719.6	719.8	720.1	720.3	720.6	720.8	721.1
.4.....	721.4	721.6	721.9	722.1	722.4	722.6	722.9	723.1	723.4	723.6
.5.....	723.9	724.1	724.4	724.7	724.9	725.2	725.4	725.7	725.9	726.2
.6.....	726.4	726.7	726.9	727.2	727.4	727.7	728.0	728.2	728.5	728.7
.7.....	729.0	729.2	729.5	729.7	729.9	730.2	730.5	730.7	731.0	731.3
.8.....	731.5	731.8	732.0	732.3	732.5	732.8	733.0	733.3	733.5	733.8
.9.....	734.1	734.3	734.6	734.8	735.1	735.3	735.6	735.8	736.1	736.3
29.0.....	736.6	736.8	737.1	737.4	737.6	737.9	738.1	738.4	738.6	738.9
.1.....	739.1	739.4	739.6	739.9	740.1	740.4	740.7	740.9	741.2	741.4
.2.....	741.7	741.9	742.2	742.4	742.7	742.9	743.2	743.4	743.7	744.0
.3.....	744.2	744.5	744.7	745.0	745.2	745.5	745.7	745.9	746.2	746.5
.4.....	746.8	747.0	747.3	747.5	747.7	748.1	748.3	748.5	748.8	749.0
.5.....	749.3	749.5	749.8	750.1	750.3	750.6	750.8	751.1	751.3	751.6
.6.....	751.8	752.1	752.3	752.6	752.8	753.1	753.4	753.6	753.9	754.1
.7.....	754.4	754.6	754.8	755.1	755.4	755.6	755.9	756.1	756.4	756.7
.8.....	756.9	757.2	757.4	757.7	757.9	758.2	758.4	758.7	758.9	759.2
.9.....	759.5	759.7	760.0	760.2	760.5	760.7	761.0	761.2	761.5	761.7
30.0.....	762.0	762.2	762.5	762.8	763.0	763.3	763.5	763.8	764.0	764.3
.1.....	764.5	764.8	765.0	765.3	765.5	765.8	766.1	766.3	766.6	766.8
.2.....	767.1	767.3	767.6	767.8	768.1	768.3	768.6	768.8	769.1	769.4
.3.....	769.6	769.9	770.1	770.4	770.6	770.9	771.1	771.4	771.6	771.9
.4.....	772.2	772.4	772.7	772.9	773.2	773.4	773.7	773.9	774.2	774.4
.5.....	774.7	774.9	775.2	775.5	775.7	776.0	776.2	776.5	776.7	777.0
.6.....	777.2	777.5	777.7	778.0	778.2	778.5	778.8	779.0	779.3	779.5
.7.....	779.8	780.0	780.3	780.5	780.8	781.0	781.3	781.5	781.8	782.1
.8.....	782.3	782.6	782.8	783.1	783.3	783.6	783.8	784.1	784.3	784.6
.9.....	784.9	785.1	785.4	785.6	785.9	786.2	786.4	786.6	786.9	787.1
31.0.....	787.4	787.6	787.9	788.2	788.4	788.7	788.9	789.2	789.4	789.7
.1.....	789.9	790.2	790.4	790.7	790.9	791.2	791.5	791.7	792.0	792.2
.2.....	792.5	792.7	793.0	793.2	793.5	793.7	794.0	794.2	794.5	794.8
.3.....	795.1	795.3	795.5	795.8	796.0	796.3	796.5	796.8	797.0	797.3
.4.....	797.6	797.8	798.1	798.3	798.6	798.8	799.1	799.3	799.6	799.8

Table for converting minutes to tenths of a degree.

Minutes.	Tenths of a degree.	Minutes.	Tenths of a degree.
0– 3	0	34–39	6
4– 9	1	40–45	7
10–15	2	46–51	8
16–21	3	52–57	9
22–27	4	58–59	10
28–33	5		

Example: Message containing meteorological information.

ICE,

	First message.	Coded as—	Second message.	Coded as—
Date of observation	21	21	22	22
Time of observation	13-15	5	3–6	2
Nature of ice or derelict	Single iceberg	1	Field ice	5
Position of ice or derelict	Latitude 44° 35′	446	Latitude 42° 58′	430
	Longitude 43° 15′	432	Longitude 47° 3′	470

WEATHER.

	First message.	Coded as—	Second message.	Coded as—
Date of observation	21	21	22	22
Position of ship	Latitude, 45° 13′; longitude, 42° 5′.	825	Latitude, 43° 47′; longitude, 46° 33′.	863
Direction and force of wind	E. S. E., 5	26	S. W., 2	55
Set and velocity of current	N. W., 2 m-h	82	S. S. E., 1 m-h	39
Weather	Sky clear	0	Fog	8
Barometer	765.3 mm	653	753.2 mm	532
Air temperature	15.3° C.	61	9.8° C.	50
Barometric tendency	Rise, .8	02	Fall, 2.7	56
Sea-surface temperature	1.4° C.	014	—.7° C.	507

The code of the above message sent to the Meteorological Office would thus be: Meteorology: Ice; 21514, 46432 : 22254, 30470 : weather; 21825, 26820, 65361, 02014 : 22863, 55398, 53250, 56507.

(See Plate 81.)

Article II.

SAFETY SIGNAL.

The radiotelegraph stations which have to transmit to ships information involving safety of navigation and being of an urgent character (icebergs, derelicts, cyclones, typhoons, sudden changes in the position or form of fixed obstructions or of landmarks) shall make use of the following signal, called the safety signal, repeated at short intervals 10 times at full power:

— — — (T T T)

In principle, all radiotelegraph stations receiving the safety signal, shall, if the transmission of messages by them would interfere with the receipt by any other station of the safety signal and the following safety message, keep silence, in order to allow all interested stations to receive that message. This does not apply to cases of distress.

The safety message shall be transmitted one minute after the safety signal has been sent out, and shall be repeated thereafter three times at intervals of 10 minutes.

The Governments of the Contracting States will select the stations which are to send out to mariners safety information of an urgent character.

When the information in question has been sent out by stations performing the time service, it shall be again sent out after the transmission of the time signal and the weather report.

Article III.

MORSE CODE.

INTERNATIONAL SIGNALS.

These signals may be made at night or in thick weather, either by long and short flashes of light, or by long and short sound signals (whistles, fog horns, etc.), or during the day by haul flags.

1. Urgent and important signals.

You are standing into danger ..... – – —
I want assistance; remain by me ..... – – – —
Have encountered ice ..... – — —
Your lights are out (*or,* burning badly) ..... – — — –
The way is off my ship; you may feel your way past me ..... – — –
Stop (*or,* heave to); I have something important to communicate ..... – — – –
Am disabled; communicate with me ..... – – — –

2. General signals.

Meaning.	Signal.	Equivalent letters and how made.	How answered.
Preparative.....	– – – – – – – – – etc.	A succession of E's in one group.	By the general answer T.
Answer.....	—	T (singly).	
Spelling	– – — – – – – —	F F in one group.....	By the general answer T.
Use International Code of Signals	— — — — — —	M M M in one group.....	By the general answer T.
International Code Flag Sign.	— — — —	M M in one group.	
Break sign	– – – –	I I as separate letters.	
Stop.....	– – – – – –	I I I as separate letters.	
Finish of the message	– – – —	V E as one group.....	– – — R. — – – D. As separate letters.
Erase sign.....	– – – – etc.	A succession of E's as separate letters.	By a succession of E's as separate letters.
Annul.....	W W – — — – — —	W W as one group.....	By W W as one group.
Repeat word after—(when a single word is required).	I M I – – — — – – W A – — — – — Followed by the word preceding the one required.	I M I as one group ..... W A as separate letters....	By the general answer T.
Repeat all after—(if more than one word is required).	I M I – – — — – – A A – — – —	I M I as one group ..... A A as separate letters....	By the general answer T.
Repeat all—(if the whole message is to be repeated).	I M I – – — — – – A L L – — – – — – – — – –	I M I as one group ..... A L L as separate letters...	By the general answer T.

3. Nationality signals.

Meaning.	Signal.	Equivalent letters and how made.
American	— — — — — —	C D as separate letters.
Argentinian	— — — — — — —	C G as separate letters.
Austro-Hungarian	— — — — — — — —	C F as separate letters.
Belgian	— — — — — — —	D C as separate letters.
Brazilian	— — — —	D E as separate letters.
British	— — — —	F.
Bulgarian	— — — — — — —	D F as separate letters.
Chilean	— — — — — —	D G as separate letters.
Chinese	— — — — —	E C as separate letters.
Colombian	— — — —	E D as separate letters.
Danish	— — — — —	E F as separate letters.
Dutch	— — — —	E G as separate letters.
French	—	E.
German	— — —	G.
Greek	— — — — — — —	M M in one group followed by D.
Italian	— — — — —	C E as separate letters.
Japanese	— — — —	C.
Mexican	— — — — — — — —	F C as separate letters.
Norwegian	— — — — — — — — —	M M in one group followed by C.
Peruvian	— — — — — — —	F D as separate letters.
Portuguese	— — — — —	F E as separate letters.
Russian	— — —	D.
Siamese	— — — — — — —	F G as separate letters.
Spanish	— — — — — — — —	G C as separate letters.
Swedish	— — — — —	M M in one group followed by E.
Turkish	— — — — — —	G D as separate letters.
Uruguayan	— — — —	G E as separate letters.
Venezuelan	— — — — — — —	G F as separate letters.

4. Instructions.

1. The Urgent and Important Signals may be made without the Preparative Signal being answered if it is supposed that the person addressed cannot reply, or in other special circumstances; but in this case a pause should be made between the Preparative Signal and the message.

2. The Signal – – — – – – — – (FF) is used previous to any letters which are intended to spell words.

3. The Signal — — — — — — (MMM) is used previous to any message sent by means of the International Code of Signals.

4. The Signal — — — — (MM) means the Code Flag of the International Code of Signals, and is used as indicated in the Code Book.

5. The Break Sign is used between the address of the receiver and the text of the message, and after the message if the name of the sender is to be signalled.

6. The Stop is used, where necessary, in the text of the signal.

7. The Erase is used to cancel the last word or signal group, sent by mistake.

8. The Annul is used to cancel *all* the message.

9. Method of Answering.—Each word or signal group, when understood, is to be answered by one long flash — (T).

If a word or signal group is not answered, the sender is to repeat it until answered by a long flash.

At the end of the message, if understood, the receiver will make – — – — – –(RD).

The Erase and Annul signs are to be answered by their own signs.

10. The Nationality Signal is made immediately after the answer to the Preparatory Signal has been received, to indicate the nationality of the vessel making the signal. It is answered by the nationality signal of the vessel receiving the message.

Article IV.

A printed copy of the code of urgent and important signals shall be placed in a prominent position in the chart room of every ship.

CONSTRUCTION.

Article V.

DEFINITIONS.

The meaning of the principal technical and other expressions contained both in the Convention and in these Regulations, under the heading of Construction, is as follows:

(1) The *load water line* is the water line used in determining the subdivision of the vessel.

(2) The *length* of the vessel is the extreme length at the load water line.

(3) The *breadth* of the vessel is the extreme width from outside of frame to outside of frame at or below the load water line.

(4) The *bulkhead deck* is the uppermost continuous deck to which all transverse watertight bulkheads are carried.

(5) The *margin line* is a line drawn parallel to the bulkhead deck at side line, and 76 millimeters (equivalent to 3 inches) below the upper surface of that deck at side.

(6) The *draught* is the vertical distance from the top of keel amidships to the load water line.

(7) The *freeboard* is the vertical distance from the load water line to the margin line amidships.

(8) The *depth* of the vessel is the sum of the draught and freeboard as above defined.

(9) The *sheer* of the bulkhead deck at any point is the vertical distance between the beam at side line at that point and a line drawn parallel to the load water line at the height of the beam at side line amidships.

(10) If *block coefficient of fineness of displacement to load water line* is used, this coefficient shall be determined as follows:

$$\frac{\text{Volume of displacement to molded lines.}}{\text{Length} \times \text{Breadth} \times \text{Draught.}}$$

(11) The *permeability* of a space is the percentage of that space which can be occupied by water.

The *volume of a compartment which extends above the margin line* shall be measured only to the height of that line. *Volumes* shall be understood as volumes to molded lines.

(12) The *machinery space* is to be taken as extending in length between the extreme main transverse watertight bulkheads bounding the spaces devoted to the main and auxiliary propelling machinery, including boilers when installed.

Article VI.

FLOODABLE LENGTH.

The floodable length at any point of the vessel shall be determined taking into consideration the form, draught, and other limiting characteristics of the vessel in question.

This floodable length for a given point in a vessel with a continuous bulkhead deck is the maximum percentage of the length of the vessel (having its center at the point in question) which can be flooded under the definite assumptions hereafter set forth in Article VII without the vessel being submerged beyond the margin line.

In the case of vessels not having a continuous bulkhead deck, the floodable length must be such as to secure to the vessel in question, for each portion of its length, and for all conditions of trim after damage, a measure of safety at least equal in effectiveness to that laid down for the vessel with continuous bulkhead deck.

Article VII.

PERMEABILITY.

The definite assumptions referred to in Article VI relate to the permeabilities of the spaces in question below the margin line.

In determining the floodable length a uniform average permeability shall be used throughout the whole length of each of the three following portions of the vessel:

(1) The machinery space;

(2) The portion forward of the machinery space; and

(3) The portion abaft the machinery space.

For steam vessels the permeability of the machinery space, including the double bottom in wake thereof, shall be taken as 80 per cent. For vessels fitted with internal combustion engines the corresponding permeability shall be taken as 85 per cent, unless it is proved by actual calculation that a lower figure may be adopted, provided that in no case shall that figure be less than 80 per cent.

The permeabilities for spaces forward and aft of the machinery space shall be as follows:

(*a*) Sixty per cent in cargo spaces, bunkers (permanent or reserve), storerooms, baggage and mail rooms, chain lockers, watertight shaft or pipe tunnels, and fresh-water tanks above the double bottom.

It must be proved that the spaces just enumerated are practicable for the purpose intended and that they are in fact to be so used. The same permeability shall not be assigned to any other space without the approval of the Administration.

(*b*) Ninety-five per cent in passenger and crew spaces, peaks, trimming tanks exclusively so used, double bottoms, and all other spaces not specifically appropriated to one of the purposes indicated in the foregoing section (*a*).

If in a 'tween deck space inclosed by complete transverse permanent steel bulkheads any portion thereof is appropriated to passengers, the whole of that space shall be regarded as passenger space; and, similarly, 'tween deck spaces appropriated for the carriage of *either* passengers *or* cargo shall be regarded as passenger spaces.

Where the spaces before or abaft the machinery space below the margin line consist partly of spaces mentioned in section (*a*) and partly of spaces mentioned in section (*b*), the average percentage of permeability shall be determined separately for each end by the formula $95—35\ r$, where r is the ratio between the volume of the spaces mentioned in section (*a*) and the total volume of the space in the portion of the ship under consideration.

Article VIII.

PERMISSIBLE LENGTH OF COMPARTMENTS.

(1) The maximum permissible length of one compartment having its center at any point in the vessel's length is obtained from the floodable length (Article VI) by multiplying that length by an appropriate factor, called the *factor of subdivision.*

(2) This factor of subdivision depends on the length of the vessel, and, for a given length, varies according to the nature of the service for which the vessel is intended. This factor decreases in a regular and continuous manner—

(*a*) As the length of the vessel increases; and

(*b*) As, for a given length, the vessel departs from the type of vessel engaged in a mixed cargo and passenger service, and approaches to the type of vessel primarily engaged in the transportation of passengers.

(3) For each of the two types of vessels referred to in the previous paragraph (2) (*b*) the variation of the factor of subdivision may be expressed by a curve, of which the coordinates represent the length of the vessel and the value of the factor. The following table gives certain points on two curves the higher of which corresponds to the minimum requirements for the "mixed" type, and the lower to the minimum requirements for the "passenger" type.

Table.

A.	B.		C.	
	Meters.	*Feet.*	*Meters.*	*Feet.*
1.00	90	295	79	259
0.90	114	374	87	285
0.84	123	404	93	305
0.65	149	489	116	380
0.50	174	571	149	489
0.39	213	699	209	685
0.34	274	899	274	899

Column A gives the maximum permissible values of the factor of subdivision for the length of vessels given in Columns B and C.

Column B is applicable to vessels engaged in mixed cargo and passenger service.

Column C is applicable to vessels primarily engaged in the transportation of passengers.

(4) For a given length, the value of the factor of subdivision appropriate to a vessel between the two extreme limits will be between the values of the factors determined by the two curves before mentioned, and will be automatically fixed by a *"criterion of service"* which is to form the subject of further study.

Article IX.

(1) When the factor of subdivision is equal to or less than .5, it may be doubled in order to give at any point of the vessel's length the total length of two adjacent compartments; but, in that case, the length of the shorter compartment of any pair shall not be less than one-quarter of the total length so obtained. If one of the two adjacent compartments is situated inside the machinery space and the second is situated outside the machinery space, and the average permeability of the portion of the ship in which the second is situated differs from 80 per cent, the length of the pair of compartments shall be adjusted to the proper value by applying a suitable correction.

(2) In no case whatever shall the length of any watertight compartment exceed 28 meters (equivalent to 92 feet).

(3) When the factor of subdivision applicable to any vessel is less than .84, but more than .5, the combined length of the two foremost compartments shall not exceed the floodable length at the extreme forward end, provided also that the length of the second compartment is not greater than that permissible by Article VIII above, and not less than 3 meters (equivalent to 10 feet).

(4) When the length of the vessel is more than 213 meters (equivalent to 699 feet) but less than 251 meters (equivalent to 823 feet) the floodable length at the forward end of the vessel shall be at least 20 per cent of the vessel's length; and the vessel, forward of a bulkhead placed either at the distance of the actual floodable length abaft the stem or not nearer to the stem than 20 per cent of the vessel's length, shall be divided into at least three compartments.

(5) When the length of the vessel is equal to or greater than 251 meters (equivalent to 823 feet) the same method shall be adopted, but the floodable length shall be at least 28 per cent and the number of compartments at least four.

(6) A bulkhead may be recessed transversely, provided the sides of the recess are at a sufficient distance from the sides of the vessel.

Vertical steps are inadmissible in the main transverse watertight bulkheads of vessels to which the subdivision rules of Article VIII apply where the factor of subdivision is greater than .5, unless such arrangements are made by additional subdivision as shall maintain the same measure of safety as that secured by bulkheads without steps. The total length of the steps in any bulkhead shall not exceed 2 per cent of the vessel's length, plus 3 meters (equivalent to 10 feet).

(7) The existence of recesses or steps in a bulkhead shall in no case affect the permissible volumes of the compartments adjacent to such bulkhead, as determined by this and the preceding Article.

Article X.

If the degree of safety of a vessel is greater than that prescribed by Articles VIII and IX above, and if the owner requests that this fact be recorded on the Safety Certificate, in accordance with Article 17 (paragraph 4) of the Convention, this request shall be accompanied with all the data necessary to justify this claim.

In such case, the record shall state the fact that the subdivision is equal to or superior to that provided for a vessel of equal length in Column C of the Table in Article VIII, with an additional statement giving the length of the vessel in Column C whose factor of subdivision according to the rules would be exactly equal to that employed in determining the subdivision of the vessel in question.

Values of length and factors for lengths not specifically stated in Columns C and A respectively of the Table in Article VIII shall be obtained by interpolation.

Article XI.

PEAK AND MACHINERY SPACE BULKHEADS.

Vessels shall be fitted with a forepeak bulkhead to extend to the bulkhead deck, and to the weather deck in vessels having continuous superstructures. This bulkhead shall be placed at a distance of not less than 5 per cent of the vessel's length from the stem at the load water line.

An afterpeak bulkhead and bulkheads dividing the machinery space from the cargo and passenger spaces shall also be fitted and carried up to the bulkhead deck. The afterpeak bulkhead may, however, be stopped below the bulkhead deck, provided that it shall at least be carried to the first deck above the load water line, and that such deck forms a watertight flat from the afterpeak bulkhead to the stern, and also provided that the degree of safety of the vessel as regards subdivision is not thereby diminished.

Article XII.

FIREPROOF BULKHEADS.

In parts of a vessel above the margin line there shall be fitted fireproof bulkheads which will serve to retard the spread of fire. The mean distance between any two con-

secutive bulkheads of this description shall not be greater than 40 meters (equivalent to 131 feet). Recesses in these bulkheads shall be fireproof, and the openings in these bulkheads shall be fitted with fireproof doors.

Article XIII.

EXITS FROM WATERTIGHT COMPARTMENTS.

(1) In passenger and crew spaces a practicable means of escape for the occupants shall be provided from each watertight compartment.

(2) There shall be a means of escape for the crew from each engine room, shaft tunnel and stokehold compartment independent of the watertight doors.

Article XIV.

CONSTRUCTION AND INITIAL TESTING OF WATERTIGHT BULKHEADS.

(1) Watertight bulkheads shall be constructed in such a manner that they shall be capable of supporting, with a proper margin of resistance, the pressure due to a head of water up to the margin line.

(2) Steps and recesses in bulkheads shall be as watertight and as strong as the bulkhead at the place where each occurs.

Where frames or beams pass through a watertight deck or bulkhead, the watertightness shall be obtained by caulked angle chocks, or cast iron or steel chocks efficiently secured and rust-jointed, and not by wood or cement.

(3) Testing main compartments by filling them with water is not compulsory. A complete examination of the bulkheads shall be made by a surveyor; and, in addition, a hose test shall be made in all cases.

(4) The foremost and aftermost compartments shall be tested with water to a head up to the margin line.

Double bottoms, deep tanks, and all compartments intended to hold liquids shall be tested with water to a head 2.44 meters (8 feet) above the top of the tank or to the load water line, whichever is the greater.

(5) No change may be made in the structure of the bulkheads after the completion of the survey without the permission of the Administration.

(6) All provisions relating to main transverse watertight bulkheads shall apply to longitudinal bulkheads, so far as is practicable.

Article XV.

OPENINGS IN WATERTIGHT BULKHEADS.

(1) The number of openings in watertight bulkheads shall be reduced to the minimum compatible with the design and proper working of the vessel; satisfactory means shall be provided for closing these openings.

(2) No doors, sluice valves, manholes, or access openings are permitted—

(*a*) In the collision bulkhead below the margin line.

(*b*) In watertight transverse bulkheads dividing a cargo space from an adjoining cargo space or from a reserve bunker, except as provided in paragraph (6) of this Article.

(3) In the machinery space and apart from bunker and shaft-tunnel doors, not more

than one door may be fitted in each main transverse bulkhead within the machinery space for intercommunication, but where more than one separate shaft tunnel is fitted a door may be cut for each tunnel.

If a tunnel is fitted forward either for the purpose of pipes or as a communication passage it shall be fitted with a watertight door.

(4) The only types of watertight doors permissible are hinged doors, sliding doors, and doors of any other equivalent pattern, excluding plate doors secured only by bolts.

A hinged door shall be fitted with lever-operated catches workable from each side of the bulkhead.

A sliding door may have a horizontal or vertical motion. If hand-operated only, the door shall be capable of being operated at the door itself and also from an accessible position above the margin line. If operated by power, it shall be capable of being operated from the bridge, and by hand at the door itself and from an accessible position above the margin line. A door dropping by its own weight, and fitted with a cataract cylinder or equivalent arrangement, may be considered as being operated by power, if capable of being released from the bridge.

(5) In the case of watertight bunker doors, satisfactory arrangements shall be made by means of screens or otherwise, to prevent the coal from interfering with the closing of the doors.

(6) Hinged watertight doors in passenger, crew, and working spaces are only permitted above a deck, the under side of which, at its lowest point at side, is at least 2.13 meters (7 feet) above the load water line, and they are not permitted in those spaces below such deck.

Hinged watertight doors of specially heavy design may be fitted above the load water line in bulkheads between cargo 'tween-deck spaces. They shall be closed before the voyage commences, and kept closed while at sea by an efficient closing gear. None of these doors shall be fitted, even at the ends of the vessel, in a cargo 'tween-deck space in the amidship region of which 'tween-deck space it would not be permissible to fit such doors.

(7) All other watertight doors shall be sliding doors.

(8) (*a*) When the number of watertight doors in the main transverse watertight bulkheads at or about the stokehold level in the machinery space exceeds five, excluding the watertight doors at the entrances of tunnels, all watertight doors situated below the load water line shall be capable of being simultaneously closed from a station situated on the bridge, and their opening and closing shall be indicated at that station. The simultaneous closing of these doors shall be preceded by a warning sound signal.

(*b*) If watertight doors which have sometimes to be open at sea for the purpose of trimming coal are fitted between bunkers in the 'tween decks below the bulkhead deck, these shall be operated by power. The opening and closing of these doors shall be recorded in the official log.

(*c*) When trunkways in connection with refrigerated cargo are carried through more than one main transverse watertight bulkhead, and the sills of the openings are less than 2.13 meters (7 feet) above the load water line, the watertight doors at such openings shall be operated by power.

(9) Portable plates on bulkheads shall not be permitted except in machinery spaces. Such plates shall always be in place before the vessel leaves port, and shall not be removed at sea except in case of urgent necessity. The necessary precautions shall be taken in replacing them to insure that the joint shall be perfectly watertight.

(10) All watertight doors shall be kept closed during navigation except when necessarily opened for the working of the vessel, and shall always be ready to be immediately closed.

(11) If trunkways for forced draught, for access from crew's accommodation to the stokehold or for any other purpose, are carried through the main transverse watertight bulkheads, the integrity of the watertight bulkheads shall be maintained by watertight doors or other equally effective means.

(12) Where pipes, electric-light cables, etc., are carried through transverse watertight bulkheads below the margin line, arrangements shall be made to insure the integrity of the watertightness of the bulkheads.

(13) The number of sluice valves in watertight bulkheads shall be reduced to the minimum, and shall not be allowed except in positions where they are sufficiently accessible at all times to allow of its being ascertained that they are in good order. They shall be strongly constructed, efficiently fitted, and regularly inspected. Satisfactory provision shall be made for operating them from an accessible position above the margin line. Means shall be provided for indicating when they are open or shut.

Article XVI.

openings in vessel's side.

(1) (*a*) Subject to clause (*b*) below, when side scuttles are fitted below a deck the under side of which at its lowest point at side is less than 2.13 meters (7 feet) above the load water line, they shall be permanently fixed.

(*b*) Side scuttles which are capable of being opened may be fitted in the positions defined in clause (*a*), provided that—

They shall be closed watertight and locked before the vessel leaves port; they shall not be opened during navigation; the time of opening such scuttles in port and of closing and locking them before the vessel leaves port shall be entered in the official log; the construction of such scuttles shall be such as effectively to prevent any person opening them without the consent of the master.

(*c*) Scuttles fitted in the positions defined in clause (*a*) shall be provided with efficient metal shutters.

(2) In 'tween decks above the deck mentioned in paragraph (1) (*a*) of this article, opening side scuttles may be fitted except in spaces exclusively devoted to the carriage of cargo or coal.

(3) No side scuttles shall be fitted in any spaces which are exclusively devoted to the carriage of cargo or coal.

(4) All side scuttles which are not accessible during navigation shall be fitted with efficient metal covers, and both the glass and the cover shall be kept closed during navigation.

(5) No automatic ventilating scuttles shall be fitted in the ship's side below the margin line.

(6) All inlets and discharges in the side shall be arranged so as to prevent any accidental admission of water into the vessel.

(7) The number of scuppers, sanitary discharges, and other similar openings in the

side shall be reduced to the minimum, either by making each discharge serve for as many as possible of the sanitary and other pipes or in any other satisfactory manner.

(8) Discharges led through the vessel's skin from spaces below the margin line shall be fitted with efficient and accessible means for preventing water from passing inwards. It is permissible to have either one valve, fitted with a means of working it at a distance, or two valves without such gear, one of these valves being always accessible. In either case, the accessibility of the valves or of the means of working shall be assured by their being situated above the deck referred to in paragraph (1) (*a*) of this Article.

(9) In no case shall gangway, cargo, and coaling ports be fitted below the load water line. None of these ports shall be fitted, even toward the ends of the vessel, in a space below the lowest 'tween deck space in the amidship region of which it is permissible to fit such ports.

(10) Gangway, cargo, and coaling port in the vessel's side below the margin line shall be effectively closed and made secure before the vessel leaves port, and kept closed during navigation.

(11) The inboard openings of ash shoo s, rubbish shoots, etc., shall not be lower than the deck referred to in paragraph (1) (*a*) of this Article. They may be permitted above this deck if fitted, to the satisfaction of the Administration, with covers, which shall be watertight if below the margin line. Such covers shall be so arranged as to prevent their being clogged in any way, and shall be at least as easily and effectively closed as watertight doors and side scuttles.

Article XVII.

CONSTRUCTION AND TESTS OF WATERTIGHT DOORS, SIDE SCUTTLES, ETC.

(1) The design and the materials used in the construction of watertight doors, side scuttles, gangway, coaling and cargo ports, valves, pipes, ash and rubbish shoots shall be to the satisfaction of the Administration.

(2) Watertight doors shall be tested by a water pressure equal to that prescribed for the bulkhead where the doors are located. The test shall be made before the vessel is put in service, and either before or after the door is fitted.

Article XVIII.

CONSTRUCTION AND INITIAL TESTS OF WATERTIGHT DECKS, TRUNKS, ETC.

(1) Watertight decks, trunks, and ventila ors shall be of the same strength as the watertight bulkhead at the place where they occur. The means used for making them watertight and the arrangements adopted for closing the openings in them shall be to the satisfaction of the Administration. If watertight covers are used for closing these openings, they shall be fitted before the vessel leaves port, and kept closed during navigation.

(2) After completion a hose or floodi ıg test shall be applied to watertight decks and a hose test to watertight trunks. Watertight ventilators and trunks shall be carried at least up to the margin line.

(3) No change shall be made in the structure of watertight decks, trunks and ventilators after the survey without the permission of the Administration.

Article XIX.

PERIODICAL OPERATION AND INSPECTION OF WATERTIGHT DOORS, ETC.

In all vessels defined in Article 2 of the Convention, drills for the operating of watertight doors, side scuttles, valves, and closing mechanisms of scuppers, ash shoots and rubbish shoots, shall take place periodically during the voyage. A complete drill shall take place before leaving port, a second as soon as practicable after leaving port, and others thereafter at least once a week during the voyage, provided that all watertight power doors and hinged doors in main transverse bulkheads in use at sea shall be operated daily.

The watertight doors and all mechanisms and indicators connected therewith, and all valves the closing of which is necessary to make a compartment watertight, shall be periodically inspected at sea, at least once a week.

Article XX.

ENTRIES IN THE OFFICIAL LOG BOOK.

In all vessels defined in Article 2 of the Convention, hinged doors, portable plates, side scuttles, gangway, cargo and coaling ports, and other openings, which are required by the preceding rules to be kept closed during navigation, shall be closed before the vessel leaves port. The time of closing, and the time of opening (if permissible under these Regulations), shall be recorded in the official log book.

A record of all drills and inspections required by Article XIX shall be entered in the official log book with an explicit record of any defects.

Article XXI.

DOUBLE BOTTOMS.

(1) In vessels 61 meters (equivalent to 200 feet) and under 76 meters (equivalent to 249 feet) in length, a double bottom shall be fitted at least from the machinery space to the forepeak bulkhead, or as near thereto as practicable.

(2) In vessels 76 meters (equivalent to 249 feet) and under 91.5 meters (equivalent to 300 feet) in length, a double bottom shall be fitted at least outside of the machinery space and shall extend to the fore and after peak bulkheads respectively, or as near thereto as practicable.

(3) In vessels 91.5 meters (equivalent to 300 feet) and over in length, a double bottom shall be fitted amidships and shall extend to the fore and after peak bulkheads respectively, or as near thereto as practicable.

(4) In vessels over 91.5 meters (equivalent to 300 feet) in length, the inner bottom shall be continued out to the vessel's side in such manner as to protect the bilges.

(5) In vessels over 213 meters (equivalent to 699 feet) in length, the double bottom, for at least half the vessel's length amidships and forward to the forepeak bulkhead, shall extend up the vessel's sides to a height above the top of the keel not less than 10 per cent of the vessel's molded breadth.

(6) Wells constructed in the double bottom in connection with the drainage arrangements shall not extend downwards from the inner bottom more than half the depth of the

double bottom at that point. A well extending to the outer skin is, however, permitted at the after end of the shaft tunnels of screw vessels.

Article XXII.

GOING ASTERN.

Vessels shall have sufficient power for going astern to secure proper control of the vessel in all circumstances.

Article XXIII.

AUXILIARY STEERING APPARATUS.

Vessels shall be provided with an auxiliary steering apparatus, which, however, may be of less power than the main apparatus, and need not be worked by steam or other mechanical power.

Article XXIV.

INITIAL AND SUBSEQUENT SURVEYS OF VESSELS.

Every vessel defined in Article 2 of the Convention shall be subjected at least to the following surveys, as specified in detail in Article XXV below:

(*A*) A survey before the vessel is put in service;

(*B*) Periodical surveys once each year; and

(*C*) Additional surveys, as occasion arises.

Article XXV.

The surveys referred to in the previous Article shall be carried out as follows:

(*A*) *The survey before the vessel is put in service* shall include a complete inspection of the hull, machinery, and equipments, including the outside of the vessel's bottom, and the inside and outside of the boilers.

This survey shall be such as to insure that the arrangements, material, and scantlings of the hull, boilers, and their appurtenances, main and auxiliary machinery, life-saving appliances and other equipments, fully comply with the requirements of this Convention and of the detailed regulations promulgated by the Government of the contracting State to which the vessel belongs for vessels of the service for which it is intended. The survey shall also be such as to insure that the workmanship of all parts of the vessel and its equipments is in all respects satisfactory.

(*B*) *The periodical survey* shall include an inspection of the whole of the hull, boilers, machinery, and equipments, including the outside of the vessel's bottom. The survey shall be such as to insure that the vessel as regards the hull, boilers, and their appurtenances, main and auxiliary machinery, life-saving appliances, and other equipments, is in satisfactory condition and fit for the service for which it is intended, and that it complies with the requirements of this Convention, and of the detailed regulations promulgated as a result thereof by the Government of the State to which the vessel belongs.

(*C*) *A survey, either general or partial,* according to the circumstances, shall be made every time an accident occurs or a defect is discovered which affects the safety of the vessel or the efficiency or completeness of its life-saving appliances or other equipment, or any

important repairs or renewals are made. The survey shall be such as to insure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are in all respects satisfactory, and that the vessel complies in all respects with the provisions of this Convention and of the detailed regulations promulgated as a result thereof by the Government of the State to which the vessel belongs.

Article XXVI.

The detailed regulations referred to in Article XXV shall prescribe the requirements to be observed as to the initial and subsequent hydraulic tests to which the main and auxiliary boilers, connections, steam pipes, reservoirs which are subjected to high pressure, and fuel tanks for oil motors are to be submitted, as regards the test pressure to be applied, and the intervals between two consecutive tests.

Main and auxiliary boilers, connections, tanks, reservoirs, and steam piping more than 102 millimeters (4 inches) in diameter shall be satisfactorily tested by hydraulic pressure when new and thereafter periodically.

The initial and subsequent tests of the boilers shall take place under the following conditions:

The test pressure shall be not less than one and a half times the working pressure, or five atmospheres above the working pressure, whichever is the less. If the pressure at the initial test does not exceed the working pressure by more than five atmospheres, the interval between two consecutive tests shall not exceed two years. With a higher pressure at the initial test, this interval may be increased, and if the pressure at the initial test is double the working pressure, the interval may be six years, but it shall in no case exceed that period.

LIFE-SAVING APPLIANCES AND FIRE PROTECTION.

Article XXVII.

STANDARD TYPES OF BOATS.

The standard types of boats are classified as follows:

Class.	Section.	Type.
I (Entirely rigid sides.)	A	Open. Internal buoyancy only.
	B	Open. Internal and external buoyancy.
	C	Pontoon. Well deck; fixed watertight bulwarks.
II (Partially collapsible sides.)	A	Open. Upper part of sides collapsible.
	B	Pontoon. Well deck; collapsible watertight bulwarks.
	C	Pontoon. Flush deck; collapsible watertight bulwarks.

Motor boats may be accepted if they comply with the requirements laid down for boats of the first class, but only to a limited number, which number shall be determined by each Government in its own regulations.

No boat may be approved the buoyancy of which depends upon the previous adjustment of one of the principal parts of the hull, or which has not a cubic capacity of at least 3.5 cubic meters (equivalent to 125 cubic feet).

Article XXVIII.

BOATS OF THE FIRST CLASS.

The standard types of boats of the first class must satisfy the following conditions:

1A. OPEN BOATS WITH INTERNAL BUOYANCY ONLY.

The buoyancy of a wooden boat of this type shall be provided by watertight air cases, the total volume of which shall be at least equal to one-tenth of the cubic capacity of the boat.

The buoyancy of a metal boat of this type shall not be less than that required above for a wooden boat of the same cubic capacity, the volume of watertight air cases being increased accordingly.

1B. OPEN BOATS WITH INTERNAL AND EXTERNAL BUOYANCY.

The internal buoyancy of a wooden boat of this type shall be provided by watertight air cases, the total volume of which is at least equal to 7½ per cent of the cubic capacity of the boat.

The external buoyancy may be of cork or of any other equally efficient material, but such buoyancy shall not be secured by the use of rushes, cork shavings, loose granulated cork or any other loose granulated substance, or by any means dependent upon inflation by air.

If the buoyancy is of cork, its volume, for a wooden boat, shall not be less than thirty-three thousandths of the cubic capacity of the boat; if of any material other than cork, its volume and distribution shall be such that the buoyancy and stability of the boat are not less than that of a similar boat provided with buoyancy of cork.

The buoyancy of a metal boat shall be not less than that required above for a wooden boat of the same cubic capacity, the volume of the air cases and external buoyancy being increased accordingly.

1C. PONTOON BOATS, IN WHICH PERSONS CANNOT BE ACCOMMODATED BELOW THE DECK, HAVING A WELL DECK AND FIXED WATERTIGHT BULWARKS.

The area of a well deck of a boat of this type shall be at least 30 per cent of the total deck area. The height of the well deck above the water line at all points shall be at least equal to one-half per cent of the length of the boat, this height being increased to 1½ per cent of the length of the boat at the ends of the well.

The freeboard of a boat of this type shall be such as to provide for a reserve buoyancy of at least 35 per cent.

Article XXIX.

BOATS OF THE SECOND CLASS.

The standard types of boats of the second class must satisfy the following conditions:

2A. OPEN BOATS HAVING THE UPPER PART OF THE SIDES COLLAPSIBLE.

A boat of this type shall be fitted both with watertight air cases and with external buoyancy, the volume of which, for each person which the boat is able to accommodate, shall be at least equal to the following amounts.

	Cubic decimeters.	Cubic feet.
Air cases	43	1.5
External buoyancy (if of cork)	6	0.2

The minimum freeboard of boats of this type is fixed in relation to their length; it is measured vertically to the top of the solid hull at the side amidships, from the water level when the boat is loaded.

The freeboard in fresh water shall not be less than the following amounts:

Length of boat		Minimum freeboard.	
Meters.	Equivalent in feet to—	Millimeters	Equivalent in inches to—
7.90	26	200	8
8.50	28	225	9
9.15	30	250	10

The freeboard of boats of intermediate lengths is to be found by interpolation.

2B. PONTOON BOATS HAVING A WELL DECK AND COLLAPSIBLE BULWARKS.

All the conditions laid down for boats of type 1C are to be applied to boats of this type, which differ from those of type 1C only in regard to the bulwarks.

2C. PONTOON BOATS, IN WHICH THE PERSONS CANNOT BE ACCOMMODATED BELOW DECK, HAVING A FLUSH DECK AND COLLAPSIBLE BULWARKS.

The minimum freeboard of boats of this type is independent of their lengths and depends only upon their depth. The depth of the boat is to be measured vertically from the underside of the garboard strake to the top of the deck at the side amidships, and the freeboard is to be measured from the top of the deck at the side amidships to the water level when the boat is loaded.

The freeboard in fresh water shall not be less than the following amounts, which are applicable without correction to boats having a mean sheer equal to 3 per cent of their length:

Depth of boat.		Minimum freeboard.	
Millimeters.	Equivalent in inches to—	Millimeters.	Equivalent in inches to—
310	12	70	2¾
460	18	95	3¾
610	20	130	5⅛
760	30	165	6½

For intermediate depths the freeboard is obtained by interpolation.

If the sheer is less than the standard sheer defined above, the minimum freeboard is obtained by adding to the figures in the table one-seventh of the difference between the standard sheer and the actual mean sheer measured at the stem and stern post; no deduction is to be made from the freeboard on account of the sheer being greater than the standard sheer or on account of the camber of the deck.

Article XXX.

MOTOR BOATS.

When motor boats are accepted, the volume of internal buoyancy and, when fitted, the external buoyancy, must be fixed, having regard to the difference between the weight of the motor and its accessories and the weight of the additional persons which the boat could accommodate if the motor and its accessories were removed.

Article XXXI.

ARRANGEMENTS FOR CLEARING PONTOON LIFEBOATS OF WATER.

All pontoon lifeboats shall be fitted with efficient means for quickly clearing the deck of water. The orifices for this purpose shall be such that the water cannot enter the boat through them when they are intermittently submerged. The number and size of the orifices shall be determined for each type of boat by a special test.

For the purpose of this test the pontoon boat shall be loaded with a weight of iron equal to that of its complement of persons and equipment.

In the case of a boat 8.5 meters in length (equivalent to 28 feet) 2 tons of water shall be cleared from the boat in a time not exceeding the following:

	Seconds.
Type 1C	60
Type 2B	60
Type 2C	20

In the case of a boat having a length greater or less than 8.5 meters (equivalent to 28 feet) the weight of water to be cleared in the same time shall be, for each type, directly proportional to the length of the boat.

Article XXXII.

CONSTRUCTION OF BOATS.

Open lifeboats of the first class (types 1A and 1B) must have a mean sheer at least equal to 4 per cent of their length.

The air cases of open boats of the first class shall be placed along the sides of the boat; they may also be placed at the ends of the boat, but not in the bottom of the boat.

Pontoon lifeboats may be built of wood or metal. If constructed of wood, they shall have the bottom and deck made of two thicknesses with textile material between; if of metal, they shall be divided into watertight compartments with means of access to each compartment.

All boats shall be fitted for the use of a steering oar.

Article XXXIII.

PONTOON RAFTS.

No type of pontoon raft may be approved unless it satisfies the following conditions:

1. It should be reversible and fitted with bulwarks of wood, canvas or other suitable material on both sides. These bulwarks may be collapsible.

2. It should be of such size, strength and weight that it can be handled without mechanical appliances, and, if necessary, be thrown from the vessel's deck.

3. It should have not less than 85 cubic decimeters (equivalent to 3 cubic feet) of air cases or equivalent buoyancy for each person whom it can accommodate.

4. It should have a deck area of not less than 3,720 square centimeters (equivalent to 4 square feet) for each person whom it can accommodate and the platform should not be less than 15 centimeters (equivalent to 6 inches) above the water level when the raft is loaded.

5. The air cases or equivalent buoyancy should be placed as near as possible to the sides of the raft.

Article XXXIV.

CAPACITY OF BOATS AND PONTOON RAFTS.

1. The number of persons which a boat of one of the standard types or a pontoon raft can accommodate is equal to the greatest whole number obtained by dividing the capacity in cubic meters (or cubic feet), or the surface in square meters (or square feet), of the boat or of the raft by the standard unit of capacity, or unit of surface (according to circumstances), defined below for each type.

2. The cubic capacity in meters of a boat in which the number of persons is determined by the surface shall be assumed to be 0.283 times the number of persons which it is authorized to carry.

3. The standard units of capacity and surface are as follows:

Unit of capacity	Cubic meters	Equivalent in cubic feet.
Open boats, type 1A.	0.283	10
Open boats, type 1B.	0.255	9

Unit of surface.	Square meters	Equivalent in square feet.
Open boats, type 2A. Pontoon boats, type 2C.	0.325	3½
Pontoon boats, type 1C. Pontoon boats, type 2B.	0.302	3¼

4. The Government of each High Contracting Party may accept, in place of 0.302 (3¼), a smaller divisor, if it is satisfied after trial that the number of persons for whom there is seating accommodation in the pontoon boat in question is greater than the number obtained by applying the above divisor, provided always that the divisor adopted in place of 0.302 (3¼) may never be less than 0.279 (3).

The Government which accepts a lower divisor in this way shall communicate to the Governments of the other Contracting Parties particulars of the trial and drawings of the pontoon boat in question.

Article XXXV.

CAPACITY LIMITS.

Pontoon boats and pontoon rafts shall never be marked with a number of persons greater than that obtained in the manner specified in these Regulations.

This number shall be reduced—

(1) When it is greater than the number of persons for which there is proper seating accommodation, the latter number being determined in such a way that the persons when seated do not interfere in any way with the use of the oars.

(2) When, in the case of boats other than those of the first two sections of the first class, the freeboard when the boat is fully loaded is less than the freeboard laid down for each type respectively. In such circumstances the number shall be reduced until the freeboard when the boat is fully loaded is at least equal to the standard freeboard laid down above.

In boats of types 1C and 2B the raised part of the deck at the sides may be regarded as affording seating accommodation.

Article XXXVI.

EQUIVALENTS FOR AND WEIGHT OF THE PERSONS.

In the tests for determining the number of persons which a boat or pontoon raft can accommodate each person shall be assumed to be an adult person wearing a life jacket.

In verifications of freeboard the pontoon boats shall be loaded with a weight of at least 75 kilograms (165 pounds) for each adult person that the pontoon boat is authorized to carry.

In all cases two children under 12 years of age shall be reckoned as one person.

Article XXXVII.

CUBIC CAPACITY OF OPEN BOATS OF THE FIRST CLASS.

1. The cubic capacity of an open boat of type 1A or 1B shall be determined by Stirling's (Simpson's) Rule or by any other method giving the same degree of accuracy. The capacity of a square-sterned boat shall be calculated as if the boat had a pointed stern.

2. For example, the capacity in cubic meters (or cubic feet) of a boat, calculated by the aid of Stirling's Rule, may be considered as given by the following formula:

$$\text{Capacity} = \frac{l}{12}(4A + 2B + 4C)$$

l being the *length* of the boat in meters (or feet) from the inside of the planking or plating at the stem to the corresponding point at the stern post; in the case of a boat with a square stern the length is measured to the inside of the transom.

A, B, C denote respectively the *areas of the cross sections* at the quarter length forward, amidships, and the quarter length aft, which correspond to the three points obtained by dividing l into four equal parts. (The areas corresponding to the two ends of the boat are considered negligible.)

The areas A, B, C shall be deemed to be given in square meters (or square feet) by the successive application of the following formula to each of the three cross sections:

$$\text{Area} = \frac{h}{12}(a + 4b + 2c + 4d + e)$$

h being the *depth* measured in meters (or in feet) inside the planking or plating from the keel to the level of the gunwale, or, in certain cases, to a lower level, as determined hereafter.

a, b, c, d, e denote the horizontal *breadths* of the boat measured in meters (or in feet) at the upper and lower points of the depth and at the three points obtained by dividing *h* into four equal parts (*a* and *e* being the breadths at the extreme points, and *c* at the middle point, of *h*).

3. If the sheer of the gunwale, measured at the two points situated at a quarter of the length of the boat from the ends, exceeds 1 per cent of the length of the boat, the depth employed in calculating the area of the cross sections *A* or *C* shall be deemed to be the depth amidships plus 1 per cent of the length of the boat.

4. If the depth of the boat amidship exceeds 45 per cent of the breadth, the depth employed in calculating the area of the midship cross section *B* shall be deemed to be equal to 45 per cent of the breadth, and the depth employed in calculating the areas of the quarter length sections *A* and *C* is obtained by increasing this last figure by an amount equal to 1 per cent of the length of the boat, provided that in no case shall the depths employed in the calculation exceed the actual depths at these points.

5. If the depth of the boat is greater than 122 centimeters (equivalent to 4 feet) the number of persons given by the application of this rule shall be reduced in proportion to the ratio of 122 centimeters to the actual depth, until the boat has been satisfactorily tested afloat with that number of persons on board all wearing life jackets.

6. Each Administration shall impose, by suitable formulæ, a limit for the number of persons allowed in boats with very fine ends and in boats very full in form.

7. Each Administration reserves the right to assign to a boat a capacity equal to the product of the length, the breadth and the depth multiplied by 0.6 if it is evident that this formula does not give a greater capacity than that obtained by the above method. The dimensions shall then be measured in the following manner:

Length.—From the intersection of the outside of the planking with the stem to the corresponding point at the stern post or, in the case of a square sterned boat, to the after side of the transom.

Breadth.—From the outside of the planking at the point where the breadth of the boat is greatest.

Depth.—Amidships inside the planking from the keel to the level of the gunwale, but the depth used in calculating the cubic capacity may not in any case exceed 45 per cent of the breadth.

In all cases the vessel owner has the right to require that the cubic capacity of the boat shall be determined by exact measurement.

8. The cubic capacity of a motor boat is obtained from the gross capacity by deducting a volume equal to that occupied by the motor and its accessories.

Article XXXVIII.

DECK AREA OF PONTOON BOATS AND OPEN BOATS OF THE SECOND CLASS.

1. The area of the deck of a pontoon boat of type 1C, 2B, or 2C shall be determined by the method indicated below or by any other method giving the same degree of accuracy. The same rule is to be applied in determining the area within the fixed bulwarks of a boat of type 2A.

2. For example, the surface in square meters (or square feet) of a boat may be deemed to be given by the following formula:

$$\text{Area} = \frac{l}{12}(2a + 1.5b + 4c + 1.5d + 2e)$$

l being the *length* in meters (or in feet) from the intersection of the outside of the planking with the stem to the corresponding point at the stern post.

a, b, c, d, e denote the *horizontal breadths* in meters (or in feet) outside the planking at the points obtained by dividing l into four equal parts and subdividing the foremost and aftermost parts into two equal parts (a and e being the breadths at the extreme subdivisions, c at the middle point of the length, and b and d at the intermediate points).

Article XXXIX.

MARKING OF BOATS AND PONTOON RAFTS.

The dimensions of the boat and the number of persons which it is authorized to carry shall be marked on it in clear permanent characters. These marks shall be specifically approved by the officers appointed to inspect the ship.

Pontoon rafts shall be marked with the number of persons in the same manner.

Article XL.

EQUIPMENT OF BOATS AND PONTOON RAFTS.

1. The normal equipment of every boat shall consist of—

(*a*) A single banked complement of oars and two spare oars; one set and a half of thole pins or crutches; a boat hook.

(*b*) Two plugs for each plug hole (plugs are not required when proper automatic valves are fitted); a bailer and a galvanized iron bucket.

(*c*) A tiller or yoke and yoke lines.

(*d*) Two hatchets.

(*e*) A lamp filled with oil and trimmed.

(*f*) A mast or masts with one good sail at least, and proper gear for each. (This does not apply to motor lifeboats.)

(*g*) A suitable compass.

Pontoon lifeboats will have no plug hole, but shall be provided with at least two bilge pumps.

In the case of a ship defined in Article 2 of the Convention, which carries passengers in the North Atlantic, all the boats need not be equipped with masts, sails, and compasses, if the ship is provided with a radiotelegraph installation.

2. The normal equipment of every approved pontoon raft shall consist of—

(*a*) Four oars.

(*b*) Five rowlocks.

(*c*) A self-igniting life-buoy light.

3. In addition every boat and every pontoon raft shaft be equipped with—

(*a*) A life line becketted round the outside.

(*b*) A sea anchor.

(*c*) A painter.

(*d*) A vessel containing 5 liters (equivalent to 1 gallon) of vegetable or animal oil. The vessel shall be so constructed that the oil can be easily distributed on the water, and so arranged that it can be attached to the sea anchor.

(*e*) A watertight receptacle containing 1 kilogram (equivalent to 2 pounds avoirdupois) of provisions for each person.

(*f*) A watertight receptacle containing 1 liter (equivalent to 1 quart) for each person.

(*g*) A number of self-igniting "red lights" and a watertight box of matches.

Article XLI.

DAVITS.

Each set of davits shall have a boat of the first class attached to it, provided that the number of open boats of the first class attached to davits shall not be less than the minimum number fixed by the table which follows.

If it is neither practicable nor reasonable to place on a vessel the minimum number of sets of davits required by the rules, the Government of the State to which the vessel belongs may authorize a smaller number of sets of davits to be fitted, provided always that this number shall never be less than the minimum number of open boats of the first class required by the rules.

If a large proportion of the persons on board are accommodated in boats whose length is greater than 15 meters (equivalent to 50 feet) a further reduction in the number of sets of davits may be allowed exceptionally, if the Administration concerned is satisfied that the arrangements are in all respects satisfactory.

In all cases in which a reduction in the minimum number of sets of davits or other equivalent appliances required by the rules is allowed, the owner of the vessel in question shall be required to prove, by a test made in the presence of a surveyor appointed by the Government, that all the boats can be efficiently launched in a minimum time.

The conditions of this test shall be as follows:

1. The vessel is to be upright and in smooth water;

2. The time is the time required from the beginning of the removal of the boat covers, or any other operation necessary to prepare the boats for lowering, until the last boat or pontoon raft is afloat;

3. The number of men employed in the whole operation must not exceed the total number of boat hands that will be carried on the vessel under normal service conditions;

4. Each boat when being lowered must have on board at least two men and its full equipment as required by the rules.

The time allowed for putting all the boats into the water shall be fixed by a formula to be determined by the Government of each High Contracting Party, each Government undertaking to communicate its decision to the Governments of the other Contracting Parties.

Article XLII.

ADDITIONAL BOATS AND PONTOON RAFTS.

If the lifeboats attached to davits do not provide sufficient accommodation for all the persons on board, additional lifeboats of one of the standard types shall be provided. This

addition shall bring the total capacity of the boats on the vessel at least up to the greater of the two following amounts:

(*a*) The minimum capacity required by these Regulations;

(*b*) A capacity sufficient to accommodate 75 per cent of the persons on board.

The remainder of the accommodation required shall be provided either in boats of Class 1 or Class 2, or in pontoon rafts of an approved type.

Article XLIII.

MINIMUM NUMBER OF DAVITS AND OF OPEN BOATS OF THE FIRST CLASS—MINIMUM BOAT CAPACITY.

The following table fixes, according to the length of the vessel—

(A) *The minimum number of sets of davits* to be provided, to each of which must be attached a boat of the first class in accordance with Chapter VI, Life Saving Appliances, Article 47, of the Convention, and Article XLI above.

(B) *The minimum total number of open boats of the first class,* which must be attached to davits, in accordance with Article XLI above;

(C) *The minimum boat capacity required,* including the boats attached to davits and the additional boats, in accordance with Article XLII above.

Registered length of the ship.		(A.) Minimum number of sets of davits.	(B.) Minimum number of open boats of the first class.	(C.) Minimum capacity of lifeboats.	
Meters.	Feet.			Cubic meters.	Cubic feet.
31 and less than 37	100 and less than 120	2	2	28	980
37 and less than 43	120 and less than 140	2	2	35	1,220
43 and less than 49	140 and less than 160	2	2	44	1,550
49 and less than 53	160 and less than 175	3	3	53	1,880
53 and less than 58	175 and less than 190	3	3	68	2,390
58 and less than 63	190 and less than 205	4	4	78	2,740
63 and less than 67	205 and less than 220	4	4	94	3,330
67 and less than 70	220 and less than 230	5	4	110	3,900
70 and less than 75	230 and less than 245	5	4	129	4,560
75 and less than 78	245 and less than 255	6	5	144	5,100
78 and less than 82	255 and less than 270	6	5	160	5,640
82 and less than 87	270 and less than 285	7	5	175	6,190
87 and less than 91	285 and less than 300	7	5	196	6,930
91 and less than 96	300 and less than 315	8	6	214	7,550
96 and less than 101	315 and less than 330	8	6	235	8,290
101 and less than 107	330 and less than 350	9	7	255	9,000
107 and less than 113	350 and less than 370	9	7	273	9,630
113 and less than 119	370 and less than 390	10	7	301	10,650
119 and less than 125	390 and less than 410	10	7	331	11,700
125 and less than 133	410 and less than 435	12	9	370	13,060
133 and less than 140	435 and less than 460	12	9	408	14,430
140 and less than 149	460 and less than 490	14	10	451	15,920
149 and less than 159	490 and less than 520	14	10	490	17,310
159 and less than 168	520 and less than 550	16	12	530	18,720
168 and less than 177	550 and less than 580	16	12	576	20,350
177 and less than 186	580 and less than 610	18	13	620	21,900
186 and less than 195	610 and less than 640	18	13	671	23,700
195 and less than 204	640 and less than 670	20	14	717	25,350
204 and less than 213	670 and less than 700	20	14	766	27,050
213 and less than 223	700 and less than 730	22	15	808	28,560
223 and less than 232	730 and less than 760	22	15	854	30,180
232 and less than 241	760 and less than 790	24	17	908	32,100
241 and less than 250	790 and less than 820	24	17	972	34,350
250 and less than 261	820 and less than 855	26	18	1,031	36,450
261 and less than 271	855 and less than 890	26	18	1,097	38,750
271 and less than 282	890 and less than 925	28	19	1,160	41,000
282 and less than 293	925 and less than 960	28	19	1,242	43,880
293 and less than 303	960 and less than 995	30	20	1,312	46,350
303 and less than 314	995 and less than 1,030	30	20	1,380	48,750

When the length of the vessel exceeds 314 meters (equivalent to 1,030 feet) the Government of the State to which the vessel belongs shall determine the minimum number of sets of davits and of open boats of the first class for that vessel; full particulars of its decision shall be communicated to the Governments of the other Contracting Parties

Article XLIV.

HANDLING OF BOATS AND RAFTS.

The arrangements for launching boats on either side of the vessel may be made either by means of appliances for transferring the boats or rafts from one side of the deck to the other, or by stowing some of the boats not under davits, or rafts, in rows across the deck or by any other equally satisfactory means.

The davits and other appliances for lowering the boats shall be placed on one or more decks in such positions that the handling of the boats can be satisfactorily carried out. They shall not be placed in the bows of the vessel or in places where the proximity of the propellers might constitute a danger to the boats at the time of launching. Boats may be stowed on more than one deck only on condition that proper measures are taken to prevent boats on an upper deck damaging those stowed below them.

If several boats are served by the same set of davits arrangements shall be made to prevent the falls fouling when they are recovered.

Article XLV.

LIFE JACKETS AND LIFE BUOYS.

1. A life jacket shall satisfy the following conditions:

(*a*) It shall be of approved material and construction;

(*b*) It shall be capable of supporting in fresh water for 24 hours 6.8 kilograms of iron (equivalent to 15 pounds avoirdupois).

Life jackets the buoyancy of which depends on air compartments are prohibited.

2. A life buoy shall satisfy the following conditions:

(*a*) It shall be of solid cork or any other equivalent material;

(*b*) It shall be capable of supporting in fresh water for 24 hours at least 14 kilograms (equivalent to 31 pounds avoirdupois) of iron.

Life buoys filled with rushes, cork shavings or granulated cork, or any other loose granulated material, or whose buoyancy depends upon air compartments which require to be inflated, are prohibited.

3. The minimum number of life buoys with which vessels are to be provided is fixed by the following table:

Length of the vessel.		Minimum number of buoys.
Meters.	Equivalent in feet.	
Under 122	Under 400	12
122 and under 183	400 and under 600	18
183 and under 244	600 and under 800	24
244 and over	800 and over	30

4. All the buoys shall be fitted with beckets securely seized. At least one buoy on each side shall be fitted with a life line of at least 27.5 meters (15 fathoms) in length. The number of luminous buoys shall be not less than one-half of the total number of life buoys, and in no case less than six. The lights shall be efficient self-igniting lights which cannot be extinguished in water, and they shall be kept near the buoys to which they belong, with the necessary means of attachment.

5. All the life buoys and life jackets shall be so placed as to be readily accessible to the persons on board; their position shall be plainly indicated so as to be known to the persons concerned.

The life buoys shall always be capable of being rapidly cast loose, and shall not be permanently secured in any way.

Article XLVI.

EXEMPTIONS APPLICABLE TO EXISTING VESSELS.

The exemptions allowed in the case of existing vessels, as provided by Article 52 of the Convention, are as follows:

(*a*) Until the 1st January, 1920, boats and rafts which have been accepted by the Administration of one of the Contracting States on board an existing vessel may be accepted, respectively, in lieu of the lifeboats and pontoon life rafts prescribed by this Convention.

(*b*) Until the 1st January, 1920, the requirements that pontoon lifeboats should have the bottom and deck made in two thicknesses with textile material between, and that they should have the minimum freeboard specified need not be insisted upon in the case of pontoon boats accepted in accordance with the preceding paragraph (*a*).

(*c*) In the case of vessels between 75 meters (245 feet) and 140 meters (460 feet) in length, the minimum number of sets of davits may be reduced by one, below the figure given in column B of the table in Article XLIII above. In the case of vessels of 140 meters (460 feet) or more in length this number may be reduced by one on each side. These reductions shall only be allowed if proper provision is made for launching the boats.

(*d*) The provisions of Articles 42 and 49 of the Convention, respecting the launching of boats, shall not be applicable to existing vessels.

Article XLVII.

CERTIFICATED LIFEBOAT MEN.

In order to obtain the special lifeboat man's certificate provided for in Chapter VI, Life Saving Appliances, Article 54, of the Convention, the applicant must prove that he has been trained in all the operations connected with launching lifeboats and the use of oars; that he is acquainted with the practical handling of the boats themselves; and, further, that he is capable of understanding and answering the orders relative to lifeboat service.

There shall be for each boat or raft a number of lifeboat men at least equal to that specified in the following table:

If the boat or raft carries—	The minimum number of certificated lifeboat men shall be—
Less than 61 persons	3
From 61 to 85 persons	4
From 86 to 110 persons	5
From 111 to 160 persons	6
From 161 to 210 persons	7

and, thereafter, one additional certificated lifeboat man for each additional 50 persons.

Article XLVIII.

MANNING OF BOATS.

An officer, petty officer, or seaman shall be placed in charge of each boat or pontoon raft; he shall have a list of its crew, and shall see that the men placed under his orders are acquainted with their several duties and stations.

A man capable of working the motor shall be assigned to each motor boat.

The duty of seeing that the boats, pontoon rafts, and other lifesaving appliances are at all times ready for use shall be assigned to one or more officers.

Article XLIX.

FIRE DETECTION AND EXTINCTION.

1. A continuous patrol system shall be organized so that any outbreak of fire may be promptly detected.

2. Every vessel shall be provided with powerful pumps operated by steam or other means. On vessels of less than 4,000 tons there shall be two, and on larger vessels three of these pumps. The pumps shall be capable of delivering a sufficient quantity of water in two powerful jets simultaneously in any given part of the vessel, and shall be available for immediate use before the vessel leaves port.

3. The service pipes shall permit of two powerful jets of water being simultaneously directed on any given part of a deck occupied by passengers and crew, when the watertight and fireproof doors are closed. The service pipes and hoses shall be of ample size and made of suitable material. The branches of the pipes shall be so placed on each deck that the fire hose can be easily coupled to them.

4. Provision shall be made whereby both two powerful jets of water and a sufficient supply of steam may be conveyed to every space filled with cargo. Provision for the supply of steam need not be required in vessels of less than 1,000 tons.

5. A sufficient number of portable fluid fire extinguishers shall be provided, at least two being carried in each machinery space.

The Governments of the High Contracting Parties may accept other types of extinguishers provided that it is evident after trial that such extinguishers are as effective as the type referred to above. A Government which accepts a new type of extinguisher shall send a description of the apparatus and particulars of the trial to the Governments of the other Contracting Parties.

6. Two equipments, consisting of a smoke helmet and a safety lamp, shall be carried on board and kept in two different places.

7. All the fire-extinguishing appliances shall be thoroughly examined at least once each year by an inspector appointed by the Government.

Article L.

MUSTER LIST.

The muster list shall assign duties to the different members of the crew in connection with—

(*a*) The closing of the watertight doors, valves, etc.

(*b*) The equipment of the boats and rafts generally.

(*c*) The launching of the boats attached to davits.

(*d*) The general preparation of the other boats and the pontoon rafts.

(*e*) The muster of the passengers.

(*f*) The extinction of fire.

The muster list shall assign to the members of the stewards' department their several duties in relation to the passengers at a time of emergency. These duties shall include—

(*a*) Warning the passengers.

(*b*) Seeing that they are dressed and have put on their life-jackets in a proper manner.

(*c*) Assembling the passengers.

(*d*) Keeping order in the passages and on the stairways, and, generally, controlling the movements of the passengers.

The muster list shall specify definite alarm signals for calling all the crew to their boat and fire stations, and shall give full particulars of these signals.

Article LI.

MUSTERS AND DRILLS.

Musters of the crew at their boat and fire stations, followed by boat and fire drills respectively, shall be held at least once a fortnight, either in port or at sea. An entry shall be made in the official log book of these drills, or of the reasons why they could not be held.

Different groups of boats shall be used in turn at successive boat drills. The drills and inspections shall be so arranged that the crew thoroughly understand and are practised in the duties they have to perform, and that all the boats and pontoon rafts on the ship with the gear appertaining to them are always ready for immediate use.

SAFETY CERTIFICATES.

ARTICLE LII.

STANDARD SAFETY CERTIFICATE.

(Official Seal) (Country)

SAFETY CERTIFICATE.

Issued under the provisions of the

INTERNATIONAL CONVENTION FOR SAFETY OF LIFE AT SEA.

Signed at London, 20th January, 1914.

Name of vessel.	Signal letters. (International code).	Port of registry.	Gross tonnage.

I, the undersigned,.....certify:
(Name)

I. That the above-mentioned vessel has been duly surveyed in accordance with the provisions of the International Convention referred to above;

II. That the survey showed that the vessel complied with the requirements of the said Convention as regards—

(1) The hull, watertight subdivision, main and auxiliary boilers and machinery:

Convention, Article 17, and annexed Regulations, Article X.	(To be filled up only on the request of the owner).	
Lengths.	Meters.	Equivalent in feet to—
(1) of the vessel for which this certificate is issued..		
(2) of the standard vessel (column C of the Table in Art. VIII of the Regulations) the factor of subdivision of which has been employed in the case of the vessel for which this certificate is issued		

(2) The boats and life-saving appliances:

..... boats capable of accommodating.....persons.
..... rafts capable of accommodating.....persons.
..... life buoys.
..... life jackets.

(3) Radiotelegraph installation:

	Class and numbers required by Articles 33 and 34 of the said Convention.	Actual class and numbers.
Class of ship:		
Number of { operators of the first class		
Number of { operators of the second class..		
Number of { certificated watchers.....		

III. That in all other respects the vessel complies with the requirements of the said Convention, so far as those requirements apply thereto.

This certificate is issued under the authority of the..... Government. It will remain in force until.....

The undersigned declares that he is duly authorized by the said Government to issue this certificate.

Issued at .....the..... day of .....

.....
(Signature)

[For identical signatures, see p. 235.]

FINAL PROTOCOL.

At the moment of signing the Convention for the Safety of Life at Sea, concluded this day, the undersigned Plenipotentiaries have agreed as follows:

I.

The voyages referred to in Article 2 of this Convention include those from a port situated in a Colony, a Possession, or a Protectorate in which the Convention is in force to a port situated outside of that Colony, Possession, or Protectorate and conversely.

II.

In so far as the ratification of this Convention is concerned a special delay is granted to the Danish Government which shall have the right of ratifying it until the 1st of April, 1915.

III.

This Convention shall not apply to vessels registered in a Colony, Possession, or Protectorate in which the Convention is not in force.

In witness whereof the Plenipotentiaries have drawn up this final Protocol which shall have the same force and validity as if the provisions thereof had been inserted in the text itself of the Convention to which it belongs, and they have signed it in a single copy which shall remain deposited in the archives of the British Government and a copy of which shall be transmitted to each Party.

Done at London, January 20, 1914.

[For identical signatures, see p. 235.]

The Conference makes the following recommendations:

1.

As Regards Safety of Navigation:

The Government of the United States and the Directors of the Suez Canal Company should be asked to publish at Colon, at Panama, and at Suez notices giving every four hours the barometric pressure with the necessary corrections for temperature and the height above the level of the sea.

2.

The attention of the Governments which have adopted the regulations for preventing collisions at sea should be drawn to the necessity of revising these rules and in particular as regards—

1. Lights on sailing vessels;
2. Signals to indicate the course of a ship in fog;
3. Regulations relating to war vessels navigating without lights;
4. Navigation in the vicinity of war vessels;
5. Regulations relating to submarines;
6. The adaptation of lights and sound signals to the dimensions and speed of modern vessels.

3.

The Administrations concerned should continue to take steps to insure that the power of lights and sound signals employed on board vessels shall comply fully with the requirements of the international regulations for preventing collisions at sea.

4.

In view of the diversity of practice and of the opinion in the different countries, the question of the adoption of a uniform system of helm orders should be considered at the same time as the revision of the regulations for preventing collisions at sea.

5.

In districts where fog is frequent every lightship on an important outside station should be furnished with a submarine bell.

6.

Every large vessel defined by Article 2 of this Convention should be furnished with searchlights for use in rescue work and other urgent cases.

7.

Binoculars should not be provided for lookout men.

8.

The tests in use for visual acuity and color perception for officers and lookout men should be made general.

9.

The question of rendering harbor and tide signals uniform should be considered by the different Governments.

10.

The Governments of the High Contracting Parties should consider the question of approaching the companies and shipowners concerned with a view to securing that vessels crossing the North Atlantic shall not pass over the banks of Newfoundland during the fishing season.

11.

The international services provided for in Articles 6 and 7 of the Convention should, if possible, be established in time for the seasons of 1914 and 1915.

12.

The International Load Line Conference, which the British Government proposes to convene as soon as the necessary preliminary work is completed, should deal also if possible with deck cargoes of timber and wood.

As Regards Radiotelegraphy:

13.

The Governments of the Contracting States should make the necessary representation to the International Meteorological Committee that it should consider the increase of the number of stations able to send weather messages to vessels at sea and the best distribution of these stations.

14.

In support of the recommendations of the International Time Conference held at Paris in 1912—

1. A radiotelegraph meteorological service should be established, according to the provisions of Article XLV of the Regulations annexed to the London Radiotelegraph Convention.

2. Foreign-going sail and steam vessels should be equipped with an apparatus for the reception of time and weather signals.

15.

The attention of the Governments of the Contracting States should be drawn to the desirability of making every effort to reduce the delays allowed by Article 38 of this Convention for the installation of radiotelegraph apparatus and the provision and training of operators for ships of the First and Second Classes, as well as those provided in the same Article for the installation of the aforesaid apparatus, the provision and training of operators and the establishment of a continuous watch on ships of the Second and Third Classes.

As Regards Life-Saving Appliances:

16.

The attention of each of the Governments of the Contracting States should be drawn to the desirability of applying at the earliest possible moment the provisions of the Convention relating to the handling of lifeboats and lifeboat drills and fire drills as well as the provisions to prevent, to discover, and to extinguish fires.

In witness whereof the Plenipotentiaries have decided that the above recommendations should be annexed to the final Protocol in order that they may have all reasonable authority.

[For identical signatures, see p. 235.]

MESSAGE FROM THE PRESIDENT OF THE UNITED STATES

TRANSMITTING

A REPORT FROM THE UNITED STATES COMMISSIONERS TO THE INTERNATIONAL CONFERENCE ON SAFETY OF LIFE AT SEA, GIVING A SUMMARY OF THE SUBJECTS CONSIDERED AND THE CONCLUSIONS ARRIVED AT, AS EMBODIED IN THE CONVENTION.

LETTER OF TRANSMITTAL.

To the Senate:

I transmit herewith, for the information of the Senate, a report by the Commissioners of the United States to the International Conference on Safety of Life at Sea, held in London from November 12, 1913, to January 20, 1914, inclusive, with accompanying papers giving a summary of the subjects considered and the conclusions arrived at as embodied in the convention signed by the contracting States on January 20, 1914, which was sent to the Senate on March 17, 1914.

WOODROW WILSON.

THE WHITE HOUSE, *March 20, 1914.*

LETTER OF SUBMITTAL.

COMMISSIONERS OF UNITED STATES OF AMERICA,
INTERNATIONAL CONFERENCE ON SAFETY OF LIFE AT SEA,

Washington, D. C., March 18, 1914.

To the PRESIDENT,
The White House.

DEAR SIR: I beg to submit on behalf of the United States Commissioners to the International Conference on Safety of Life at Sea, held in London from November 12, 1913, to January 20, 1914, inclusive, a report giving a summary of the subjects considered and the conclusions arrived at as embodied in the convention, signed by the contracting States on January 20, 1914. This report may be helpful in arriving at a correct estimate of the value of the work accomplished by the conference.

Very respectfully,

J. W. ALEXANDER, *Chairman.*

INTERNATIONAL CONFERENCE ON SAFETY OF LIFE AT SEA.

WASHINGTON, *March 18, 1914.*

CHAPTER I.

SAFETY OF LIFE AT SEA.

To the PRESIDENT:

The convention is an international agreement signed by the accredited representatives, in the order of signature, of Germany, Austria-Hungary, Belgium, Denmark, Spain, the United States, France, Great Britain (including representatives of the Australian Commonwealth, the Dominion of Canada, and New Zealand), Italy, Norway (ad referendum), the Netherlands, Russia, and Sweden. Japan was represented at the conference, but the delegation was appointed at a late day and was not authorized by the Japanese Government to vote in the conference or committees or to sign the convention.

Ratifications are to be deposited not later than December 31, 1914 (Art. 71), and the convention will come into force on July 1, 1915 (Art. 69). The contracting States undertake to give full and complete effect to the convention (Art. 1) and to the regulations which have the same force and effect as the convention (Art. 1). The contracting States also undertake to propose or enact measures necessary to repress infractions of the requirements of the convention (Art. 65).

Each contracting State is authorized by Article 66 to designate those of its colonies to which the convention shall be applicable. Provision is made in Article 67 for the accession to the convention of States not invited to attend the London conference.

The convention has no prescribed limit of duration, but after five years may be denounced by any State which has ratified it (Art. 69). In the meantime useful or necessary improvements in the convention may be made at any time through diplomatic channels (Art. 74).

The conference recognized from the start the difficulties in the way of securing a substantial agreement among the representatives of so many nations, speaking different languages and with differing conditions of commerce and navigation, upon the many and complex problems involved in promoting the safety of life at sea. Many other matters related to the general subject, not covered or only partially covered by the convention, were brought before the several committees, which could not be disposed of within reasonable time limits. The convention is designed by the nations which framed it as a broad foundation for further co-operation, and this idea is particularly expressed in Articles 30, 64, XLIX, providing for the exchange of information to promote improvement and progress, and in Article 74. The spirit in which the conference closed its labors and in which the American delegation submits its action for consideration was expressed in the words of Lord Mersey, president of the conference, in moving the adoption of the convention:

"I may say a few more words in conclusion. Our work will no doubt be criticised. So far as the criticism originates with interested parties we can ignore it; and so far as it originates with disinterested parties, our answer must be that we have done our best, that we have done it with anxious care and, as we believe, in the true interests of those who travel by sea.

"Gentlemen, you have been engaged in perfecting a great work, which I am firmly convinced will be of lasting benefit to mankind. Much more than this, however—you have, perhaps unconsciously, but nevertheless most surely, by the spirit of courtesy and conciliation which has been displayed throughout your deliberations, contributed greatly to the increase of mutual respect and confidence among the nations, and thereby to the peace and happiness of the world at large."

Chapter II.

VESSELS TO WHICH THIS CONVENTION APPLIES.

PASSENGER VESSELS.

The convention applies to mechanically propelled (steam, motor, and internal combustion) merchant vessels which carry more than 12 passengers (Art. 2). The laws of the United States at present treat as a passenger vessel any steamer carrying even one passenger; but not infrequently the Department of Commerce remits or mitigates penalties incurred by freight steamers which carry three or four passengers between ports, as on the rivers of Alaska at certain seasons or to ports in Central America or Mexico, at which passenger steamers are not available, but to and from which Americans must proceed in the course of business. The limit of 12 persons is that fixed by British law and was the compromise accepted as against the limit of 20 proposed by others. The American delegation at the outset favored the preparation of a convention which should also apply to freight steamers. It soon became evident, however, that to draft the different rules required for freight steamers would prolong the conference much beyond the time this delegation was prepared to remain, and would also so overload the conference that much less satisfactory conclusions as to passenger steamers could be reached. This difficulty was particularly serious in the matter of hull construction, where the problems connected with cargo are somewhat different from those connected with passenger steamers. Furthermore, an international conference is to be held at London later this year to consider uniform load lines and deck loads, and Congress has provided for American representation at this conference which will consider more particularly cargo vessel problems. (See recommendation 12 after the final protocol.)

Nevertheless, cargo vessels are brought as far as practicable within the scope of the pending convention. Chapter III relating to safety of navigation applies to cargo vessels as well as passenger vessels (Art. 5), particularly in Articles 8, 9, 10, 12, and 13. Chapter V, relating to radiotelegraphy, applies to cargo vessels having on board fifty persons or more, as does the law of the United States (Art. 31).

TRADES UNDER THE CONVENTION.

The convention applies to mechanically propelled vessels carrying more than 12 passengers when in trade (Art. 2):

1. Between ports in the States signatory to the convention; that is to say, foreign trade. The question was discussed whether the convention should apply to American or British vessels in trade, for example, between Liberia and Cuba—nonsignatory States—and the American delegation favored this proposition, but yielded to the argument that it would be difficult to administer the convention rules effectively when both terminal ports were in countries which may not adopt and provide the administrative machinery to carry out the convention rules.

2. Between ports in any contracting State and ports in its colonies, possessions, or protectorates, or the colonies, possessions, or protectorates of another contracting State. In view of the extended oversea possessions of the principal powers represented the propriety of this rule will not be questioned. In the case of the United States such over-sea possessions include the Philippines, Alaska, Hawaii, Porto Rico, and the Canal Zone. Alaska, Hawaii, and Porto Rico are included under the coasting laws of the United States, and the American delegation was instructed not to commit the United States to coasting regulations. The value of the words in Article 2, "Ports situated in the colonies, possessions, or protectorates are considered to be ports outside the States of the high contracting parties," is so clear that if necessary the American delegation would have cabled for a modification of instructions to enable it to support finally this proposition. It was not necessary, however, as article 66 is so framed that Hawaii, Porto Rico, and Alaska may be excluded, if the Senate shall see fit, from the operation of the convention. The convention rules apply to vessels in trade between a colony, possession, or protectorate and ports in contracting or noncontracting States (final Protocol I), and, of course, do not apply to vessels of a colony, possession, or protectorate in respect to which the convention has not been ratified by the mother country (final Protocol III). The convention also provides in Article 3 that each State may except from the convention voyages which it is to specify at the time of ratification, subject to modification later, but no voyages shall be so exempted if the vessel goes more than 200 miles from the nearest coast. This exemption was drawn principally to cover the trade across the channel between England and the Continent, which from Brest to the River Elbe has been described as "home trade" for many years in British laws, and from the point of view of navigation shares most of the characteristics of our coasting trade. It was also designed to cover the trade within the Baltic. Our immense trade on the Great Lakes is not brought under the convention. So far as the United States is concerned there are somewhat similar voyages on Puget Sound between the United States and British Columbia, the voyages of about 90 miles between Key West and Habana, and from Eastport, Me., to St. John, New Brunswick. These voyages are mentioned in illustration, and not as recommended exemptions. The last paragraph of Article 3 enables a State which imposes the convention rules on its own ships on these short exempted routes to secure for them recognition as such ships, even if the country at the other terminal of one of these short routes sees fit to exempt its vessels from the requirements of the convention.

Chapter III.

SAFETY OF NAVIGATION.

DESTRUCTION OF DERELICTS.

For some years the Revenue-Cutter Service of the United States has been engaged in the destruction or removal of derelicts, which are usually lumber-laden vessels, though occasionally a steel steamer with miscellaneous cargo, like the burnt steamship Volturno, may become derelict. Roughly speaking the operations of this service have been to the west of a line from Sable Island to the Bermudas, along the North Atlantic coast of the United States, where such derelicts are usually afloat. Occasionally the revenue cutters have gone eastward and southward beyond these general limits. The value and efficiency of this service were appreciated by the conference, and Article 6 of the convention extends derelict destruction to the eastward, and provides that the cost of maintaining this extension of the operations of the Revenue-Cutter Service shall be met by contributions from the nations concerned in proportions fixed by Article 7, Great Britain paying 30 per cent, the United States, France, and Germany each 15 per cent, and the remaining 25 per cent being divided among other nations. From time to time other Government vessels of the several powers will also destroy derelicts when the revenue cutters are employed on other international duties.

ICE PATROL.

Following the loss of the steamship Titanic in April, 1912, the United States Government sent the scout cruisers Salem and Birmingham to maintain a patrol to the north of the North Atlantic steamship lanes to give notice by wireless to steamships of the southward course of the ice and of zones made dangerous thereby. During 1913 the same service was performed by two American revenue cutters, the entire cost for both years being borne, of course, by the United States. The value of these services was appreciated by the conference, and the United States was invited to assume this duty, together with the work of destroying derelicts, on the same basis of contributions by the maritime powers to meet the expense.

ICE OBSERVATION.

Skilled navigators and scientists are confident, partly as a result of the Arctic and Antarctic explorations of recent years, that by a thorough study and observation of ice conditions and formation, and of the Labrador and other currents, the natural laws governing the formation and movements of ice in the North Atlantic may be determined at least to the extent of permitting approximate forecasts, similar to recent meteorological forecasts, which will contribute to safer ocean navigation. The British Government sent the steamship Scotia for that purpose during the spring of 1913, but, owing to temporary handicaps and delays, its work was not as thorough as was desired. The conference requested the United States to undertake this service in connection with the ice patrol and the destruction of derelicts. These three tasks were deemed so useful that the conference (recommendation 11, after final protocol) urged their establishment during 1914 and 1915 in advance of the enforcement of the convention. The total annual cost of the three services, which will give continuous employment to two revenue cutters, has been estimated in round numbers at $200,000, of which the United States is asked to contribute $30,000, and other nations the remaining $170,000.

While the two cutters are thus employed specifically for the purposes of derelict destruction, ice patrol, and ice observation, they will at the same time, of course, be in a position often to render assistance to vessels in distress in those portions of the north Atlantic where the weather is most severe and the risks of navigation greater than on the usually pleasant and less disturbed southern routes from the Mediterranean to ports of the United States. The members of the conference, it may be added, were united in approving the work which the United States has already done along the lines just indicated, and there was no dissent from the general wish for its continuation and a general desire to contribute to the expense.

NOTICES OF PERIL.

The conference in Articles 8 and 9 imposes on the masters of merchant vessels the obligation, by all means of communication in their power, to give notice to other vessels of the existence of any imminent and serious danger to navigation. A new wireless call is provided by Article II, named safety call (— — —), which must be sent broadcast by the master of a vessel aware of the existence of imminent and serious danger. This call "T T T" has precedence over all wireless calls except the "S O S" of distress. Following the call is the message indicating the nature of the peril. Such messages are to be repeated by selected coast stations for the guidance of mariners. Messages relating to ice and derelicts must be transmitted free of cost to the vessels concerned, and if the wireless companies charge for them the expense must be borne by the governments concerned, just as other aids to navigation are maintained at public expense. The convention carries in Article I a complete code for the transmission and dissemination of information relating to ice, derelicts, and weather, and the Naval Hydrographic Office at Washington (the work of which met with the cordial approval of all nations represented) was selected as the general center for the dissemination of such information.

MORSE SIGNALING LAMPS.

Steamers carrying 12 passengers or over are required by Article 11 to carry a Morse signaling lamp. Practically all war ships and the best equipped of the large ocean passenger steamers now carry this helpful means of communication between ships at sea. The code for its use is set forth in Article III (steps have already been taken for the insertion of a signal for Cuba, which was accidentally omitted from the list of nationality signals).

DISTRESS SIGNALS.

The convention prohibits, in the future, the use of the international distress signals for any other purpose than as distress signals. This rule will prevent any vessel hesitating to respond to what is apparently an international distress signal on the supposition that it was intended for another purpose, as was the case with the master of the Californian at the time of the loss of the Titanic. (Art. 12.)

NORTH ATLANTIC ROUTES.

The conference concluded (Art. 13) that the selection of steamship routes across the North Atlantic should be left, as at present, with the steamship companies. The designation

of such routes by the Governments specially concerned was thoroughly discussed, but it was concluded that such designation might enable the master of a vessel in collision with another vessel to set up the claim that he was following a route fixed for him by Government, and that the diminution of the master's sense of responsibility would offset the advantages of government routes or lanes. Hereafter the companies concerned are required to give public notice of their routes and of any changes to be made. Each Government will use its influence to induce the owners of other vessels to follow the routes of the principal companies. At the present time this last-named requirement does not apply to the United States, as the six American trans-Atlantic steamers belong to principal companies which fix the routes.

ICE ZONES.

As an alternative to the establishment by Government of ocean lanes, the American delegation successfully urged that the rule of prudent seamanship laid down by Lord Mersey in the Titanic inquiry should be formally incorporated in the law of maritime nations, and it was incorporated as Article 10 of the convention.

"Art. 10. When ice is reported on or near his course, the master of every vessel is bound to proceed at night at a moderate speed or to alter his course, so as to go well clear of the danger zone."

This is a most important rule and will result in greater safety to navigation than prescribing fixed Government trans-Atlantic lanes, because, no matter where the ice may suddenly appear, the master of every vessel must either go at moderate speed or leave that vicinity at once.

INTERNATIONAL RULES OF THE ROAD.

The international rules for preventing collisions at sea are the result of agreements which have been ratified and are now being carried out by 26 nations and by the self-governing British dominions. The 14 principal maritime nations represented at the conference decided that it would not be fair, without consulting the maritime nations not represented, to change the rules for preventing collisions to which they had already agreed and were now enforcing. The need for changes in the rules was earnestly advocated by the American delegation, and the convention (Art. 14) provides that the assent of these nations to the modification of the rules be secured as soon as possible. The principal changes proposed are the compulsory use of range lights on steamers, now optional under international rules, but obligatory on inland waters of the United States; the compulsory use of a fixed stern light in place of the display of a light or torch at the stern to an approaching vessel, a special day signal for motor vessels, which latter do not from a distance always indicate the fact that they are vessels under control; and, finally, a special sound signal for use in a fog by a vessel in tow or by the last of several vessels in tow.

The international wireless distress signal is already in general use, and its official incorporation in the signals of the rules of the road is simply a matter of form. Some of the other changes proposed deal with the substance of the rules, and differences of opinion may arise which must be adjusted.

Besides these requirements of the convention, the conference made several recommendations for action as regards safety of navigation on matters, some of which require con-

sideration as to form and others as to substance, while still others may be met by administrative action. Thus in revising the rules for preventing collisions it is deemed necessary to take up lights on sailing vessels, signals indicating courses in fog, rules for war vessels navigating without lights, rules for other vessels when in the vicinity of war vessels, regulations to meet the increasing number of submarines, and more rigid requirements as to the power of lights and sound signals to meet the speed and size of modern vessels. (See recommendations 2 and 3 after final protocol.)

SUBMARINE BELLS.

While the American delegation was convinced of the value of submarine bells, it did not press their compulsory use, as this bell is patented and sold by only one company. In the final recommendations (No. 5) the use of this bell is recommended on lightships on important outside stations where fog is frequent. Congress has appropriated money for this purpose in the United States.

SEARCHLIGHTS.

Searchlights on large passenger steamers for rescue work and other urgent purposes are recommended in recommendation 6, but the opinion of trained seamen was against their compulsory use for purposes of navigation.

LOOKOUTS.

There was no dissent among delegates trained to the sea that more harm than possible good would result from providing binoculars to lookout men. (Recommendation 7.) The need of testing the eyesight and color vision of lookouts as well as of officers, in so far as not already provided for, is impressed in recommendation 8.

CHAPTER IV.

SAFETY OF CONSTRUCTION.

To the committee on safety of construction were assigned all subjects involving hull subdivision, structure, and fittings, as indicated in the following extract from the official "Questions before the conference":

"5. *Bulkheads and water-tight compartments.*—A special study of this question has been recently made by some of the Governments concerned. It may therefore be desirable that a special subcommittee of the conference should be appointed to examine and compare results arrived at, with a view to determining (*a*) whether the study of the question is sufficiently far advanced to enable principles of international applicability to be laid down in the case of new ocean-going passenger steamers; and if so, what those principles should be; (*b*) whether it is desirable and practicable to lay down any general principles with regard to existing ocean-going passenger steamers.

"6. *Arrangements for surveying passenger steamers.*—In view of the difference in con-

ditions prevailing in different countries, is it possible to secure a uniform system of survey at all ports? If not, will it be sufficient to lay down that the survey should be carried out, either by Government surveyors or by surveyors specially appointed by the Government for the purpose, so as to secure that in every case the Government concerned accepts full responsibility for the efficiency and completeness of the survey?

"7. *Principles which should govern the survey.*—Is it possible or desirable for the conference to lay down detailed rules governing the survey of passenger steamers in all respects; and, if not, can the conference formulate some general principles which should govern the survey of passenger steamers in the different countries as regards hull, boilers, machinery, and equipments?

"8. *Provision against breakdowns.*—It has been suggested that, at least in the case of new and large passenger steamers, it should be compulsory that certain portions of the machinery and of the equipments should be in duplicate or in two or more sections capable of working independently, so as to provide against breakdowns. Is this a question which should be left to the different administrations, or should it be dealt with by the conference; and, if the latter, can the conference formulate some general rules or principles on the matter?"

The above-noted terms of reference were unanimously adopted by the conference at its second session, it being generally recognized that some general limitation in the scope of the investigation was necessary in order that the conference might give satisfactory attention during the time available to the most important subjects under consideration.

The committee on Safety of Construction was composed of 32 members, representing 14 maritime countries. Of these 32 members, 17 were Government officials highly qualified by training and experience to pass upon all matters relating to the construction of a vessels; 2 were professors of naval architecture in royal universities; 3 were technical directors of national marine insurance and classification societies; 7 were managing directors, directors, or technical directors of large steamship companies; and 3 were shipbuilders.

The gentlemen composing this committee, practically without exception, were men who held high positions in their respective countries and they brought to their work on this international conference a comprehension of conditions which could only result from excellent professional training and large and varied practical experience. The work devolving upon this committee was especially difficult, since no previous attempt had been made to establish international regulations with respect to the principal subjects under consideration. In fact, no country had established complete regulations with respect to the most important of all subjects before the conference, viz., the subdivision of vessels into an adequate number of water-tight compartments.

Great Britain, France, and Germany had undertaken extensive and most helpful preliminary work concerning this important subject, but final conclusions had not been reached. The United States had, through a committee organized under the jurisdiction of the Department of Commerce and composed of officials of the Departments of the Navy and Commerce, submitted a preliminary report in general terms concerning some of the more important questions relating to the safety of construction. Several national classification societies, notably the Germanischer Lloyd, had done important research work and this last-named society, utilizing previous researches of the British Bulkhead Committee, had developed and promulgated subdivision rules, but no country had enacted specific laws governing the complete subdivision of various classes of vessels and the methods of maintaining the water-tight integrity of these subdivisions so that a vessel under certain conditions of damage would have a sufficient reserve of buoyancy to remain afloat.

The propositions submitted to the conference by the representatives of Great Britain, Germany, and France were dissimilar in certain vital respects. The problem of obtaining concerted action seemed, therefore, so difficult as to render it doubtful if it would be possible, in the time at the disposal of the conference, to reach definite conclusions with respect to that most important subject—the safety of construction of the ship itself. The committee intrusted with this portion of the work of the conference organized promptly and held numerous sessions. As an evidence of the degree of consideration given to this subject, it is worthy of note that the committee, through its full membership or subcommittees, held 51 formal and numerous additional informal meetings. Space does not permit nor does it seem necessary to go into the details of the work of the committee, the results attained being clearly set forth in the convention itself and the annexed regulations.

The following list of subjects considered is interesting, however, and indicates the character and extent of the work of the committee on safety of construction:

QUESTIONS FOR CONSIDERATION OF SUBCOMMITTEES.

FIRST SUBCOMMITTEE.

"1. In the subdivision of vessels into watertight compartments, latitude to be given in the use of transverse and longitudinal bulkheads and combinations of same in order that the prescribed requirements as to buoyancy under damaged conditions may be met in the most advantageous manner in any particular design. Where longitudinal bulkheads are introduced, provision of adequate transverse stability under damaged conditions to be secured.

"2. Stability calculations to be made for all vessels constructed and stability curves furnished to masters and owners of vessels, with full explanatory notes indicating condition of vessel when light and loaded under certain definite conditions, and safe limitations of loading with cargoes of various densities.

"3. Definitions: Length, breadth, depth, freeboard, draught, sheer, margin of safety line, floating line, coefficient of permeability, and any other terms of which the exact meanings may be of importance in the principles enunciated.

"4. Limit of size of ships to which rules shall be applied.

"What is the smallest length or least size of foreign-going ocean passenger vessel which can be so subdivided that under average conditions of loading she will not be submerged beyond the bulkhead deck with any (*a*) three adjacent compartments, (*b*) two adjacent compartments, (*c*) one compartment, in free communication with the sea?

"5. Lower limit of number of passengers carried. What is the smallest number of passengers or persons on board a foreign-going ocean passenger vessel that should make the vessel subject to rules as to subdivision?

"6. Method of giving practical effect to general principles enunciated in paragraphs 2 to 5 of 'suggested general principles' adopted at meeting of full committee on November 25, 1913.

"Paragraph 2. System of curves or tables for determining spacing and height of bulkheads.

"If the system of curves or tables provided is such as to take into account all the geometrical characteristics of a vessel, should direct calculations be permitted, and if so, under what conditions and limitations.

"Paragraph 3. Permeability.

"Should the permeability assumed to be based on the water-excluding properties of the various spaces, and, if so, can average coefficients of permeability be assigned to the different classes of spaces, and what should these average coefficients be?

"If the permeability assumed has some other basis than that described above, what should that basis be?

"Paragraph 4. Floating line.

"Should the floating line be fixed at some definite distance, or distance-ratio, below the bulkhead deck, for all ships, and, if so, what should this distance or distance-ratio be? If not, on what basis should the distance of the floating line from the bulkhead deck be determined in the various cases to be dealt with?

"Paragraph 5. Permissible extent of flooding. (See items (*a*), (*b*), and (*c*), Sec. 4 above.)

"7. General requirements for spacing and height of transverse bulkheads, and location and extent of longitudinal bulkheads and water-tight decks.

"8. If the permeability assumed for spaces forward and abaft the machinery spaces is such as to take correct account of the amount of cargo space and passenger space, respectively, in any vesse, is it necessary that the other two elements in subdivision (viz., distance of floating line from bulkhead deck, and number of compartments into which the floodable length is divided) should vary for vessels of the same length, but of different type or engaged in different service?

"9. Should rules as to subdivision be prescribed for vessels below the smallest length or least size covered by the questions and conditions set forth in preceding paragraphs?

SECOND SUBCOMMITTEE.

"1. Bulkheads.

"Character and construction of water-tight bulkheads (transverse, longitudinal, wing, stepped).

"Physical tests to be applied to same while under construction.

"Prohibition of changes in, except when authorized.

"2. Double bottoms. Character and extent of double bottoms. Wells.

"3. Openings in water-tight bulkheads below bulkhead deck. Water-tight bulkheads below bulkhead deck; water-tightness not to be impaired by openings, except when absolutely necessary. (1) Doors. (2) Scuttles and bolted plates. (3) Sluices. (4) Trunks (for passage of crew, forced draft, refrigeration, etc.). (5) Openings for drainage pipes, electric wires, etc.

"4. Water-tight doors. (1) Type, hinged or sliding. (2) Location (are they absolutely necessary in any main transverse water-tight bulkhead below bulkhead deck; if so, where, and with what restrictions?) (3) Material used in their construction. (4) Operation (hand, mechanical, automatic). (5) Stations from which operated. (6) Necessary general features of design. (7) Indicating and alarm system and emergency control. (8) Character and frequency of inspection and tests of water-tight door system, and all mechanism and indicators connected therewith. (9) General water-tight door closing drills. (10) Record of all tests and drills to be entered in log, and note made where doors or mechanism are out of order. (11) Are they to be kept closed except when opening necessary for working of vessel. (12) Shall water-tight doors be closed at night, in foggy weather, and when in vicinity of icebergs?

"5. Water-tight decks. (1) Location, character, strength, and tests. (2) Location and method of closing openings in same. (3) Scuppers. (4) Preservation of water-tight integrity by prohibiting unauthorized changes in same, and note made in ship's log of all changes affecting water-tight integrity.

"6. Openings in side. (1) Side scuttles, chutes, scuppers, etc.; when permissible, and location with respect to water line. (2) Air ports; when permissible, and location with respect to water line.

"7. Machinery spaces. (1) Division of bulkheads. (2) Grouping of boiler rooms with respect to water-tight compartments. (3) Maximum length of water-tight compartments in machinery space. (4) Practicability and desirability of wing bulkheads in vessels of broad beam.

THIRD SUBCOMMITTEE.

"Questions contained in paragraphs 6, 7, and 8 of 'Questions before the conference.'

"1. Establishment of uniform code of general requirements.

"2. Possible inclusion in the 'National certificate' referred to in Section (*a*), paragraph 4, of 'Questions before the conference' of items which will cover the specific requirements as to hull, machinery, fittings, etc., which may be adopted by the conference.

"3. In large new passenger steamers, engineering considerations will possibly control and compel duplication of propelling machinery. General rules for duplication of pumps, dynamos, steering engines, and other auxiliaries to be considered."

Earnest and intelligent cooperation in the consideration of the whole subject of safety of construction, including the questions above enumerated, produced the desired results. Definite conclusions were reached. These conclusions do not, of course, represent the highest attainable standards; such is hardly to be expected in work of this character which involves ultimately so much modification of previous practice, development of details and adjustment to many and varied local conditions in the countries represented at the conference.

Distinct and great progress has been made, however, in securing greater safety of construction in vessels hereafter built. Standards of efficiency have been fixed and these standards will be enforced by enactment of the necessary laws upon the ratification of this convention by each of the signatory states. In other words, the ratification of the work of the conference by the signatory states will impose upon all of the principal maritime countries an obligation to enact into law requirements which will establish standards superior to those previously prescribed or prevailing, even in those countries which had taken the most advanced position in such matters. This in itself may be regarded as an important and most desirable achievement without even entering into the merits of the standards adopted. But the conference did not stop when it fixed certain minimum requirements as to the construction of vessels. It went much further and provided the international machinery for further investigation and improvement. By specific phraseology (Art. 17 of convention and Art. X of regulations) it is also provided that for vessels whose degree of safety, through more efficient subdivision, is greater than that prescribed by the convention for vessels of their size, this increase of safety shall be indicated on the "Safety Certificate" of the vessel by the proper Government officials. Here is a direct and powerful stimulus to shipbuilders and shipowners to exceed the requirements of the convention, for there is little doubt that a discriminating traveling public will give greatest encouragement to those steamship companies which show a strong desire to increase the safety of their vessels.

It will be noted that the language of the convention so far as concerns the chapter on "Construction" is unusually concise and, in many instances, gives only a general idea of requirements which are set forth at greater length in the regulations. This more or less brief reference in the convention was not due to any failure on the part of the conference to realize the importance of the subject. On the contrary, the original tentative draft of the convention by the "committee on redaction" placed in the convention itself a large part of the matter now found in the regulations. Such an arrangement, however, obviously interfered with the natural and orderly sequence of the articles covering the subjects considered. It was therefore subsequently decided unanimously to arrange the articles in the convention and the regulations as they now appear and to incorporate in Article 1 of the convention the following proviso:

"The provisions of this convention are completed by regulations which have the same force and take effect at the same time as the convention. Every reference to the convention implies at the same time a reference to the regulations annexed thereto."

Brief reference will now be made to the individual articles of the convention and the regulations. As a rule the language is quite explicit and self-explanatory. In some instances, however, the treatment of purely technical matters in technical language may not be altogether clear to those not thoroughly versed in such matters.

Article 16 of the convention is the first article of Chapter IV, a chapter which embraces all matters under "Construction" which were treated by the conference. This article, in connection with Articles 2, 3, and 4 of the convention, defines the vessels to which the requirements of the convention are applicable. The language is clear and specific. No comment seems necessary other than to emphasize the fact that the requirements of the convention, in their entirety, are applicable to all "new vessels," whereas "existing vessels" are subject to such requirements as may be imposed by the governments of their respective countries. The question of the reference to their respective countries of such detailed consideration of existing ships as might seem necessary was fully discussed and it was finally determined that such action was the only practicable one.

Article 17 of the convention relates to the subdivision of ships and is largely supplemented by the provisions of Articles V-X of the regulations. Mention has already been made of the great difficulty involved in reaching a satisfactory agreement with respect to this highly important subject of "subdivision of vessels." It is a very complex question when the object in view is the formulation of regulations which are subsequently to be enacted into laws which shall have full force and effect in the principal maritime nations of the world.

At the very beginning it was recognized that the three most important elements to be considered were the "margin of safety," the number of compartments which could be flooded without destroying the reserve buoyancy of the vessel, and the "permeability" to be assigned to the various spaces below the "margin line" in making calculations affecting the spacing of bulkheads. For all practical purposes the "margin of safety" is indicated by the location of the bulkhead deck, a deck which is thus defined in paragraph 4, Article V, of the regulations:

"The bulkhead deck is the uppermost continuous deck to which all transverse water-tight bulkheads are carried."

"Permeability" is thus defined in paragraph 11, Article V, of the regulations:

"The permeability of a space is the percentage of that space which can be occupied by water."

The determination of the percentages to be allowed for "permeability" therefore involved one of the most important fundamental considerations. The conference greatly increased this percentage over and above what had previously been considered necessary. Increase in the value of the "permeability" percentages which are permitted to be used in the "flooding calculations" of ships means a corresponding increase in the reserve buoyancy of a vessel. Some idea can be formed of the increased buoyancy resulting from this one item when it is stated that for cargo spaces this permeability percentage has been increased from 40 per

cent to 60 per cent, and for the spaces in the double bottoms and trimming tanks there has been an increase from 40 per cent to 95 per cent. This great increase in the values assigned to "permeability percentages" must be given due weight when considering the "permissible length of compartments" provided for in Article VIII of the Regulations. At first sight, the "factors of subdivision" given in the table of paragraph 3 of Article VIII may appear unduly large, since efficiency of subdivision is inversely as the value of the factor of subdivision. The American delegation was very desirous of agreeing upon more stringent requirements in this respect, but the data and experience available convinced their colleagues of other countries that the requirements of paragraph 3, Article VIII, were as high as could reasonably be imposed. These requirements, however, as well as those of Article IX, were distinctly specified as minimum requirements, and Article X made definite provision for making official notation on the "Safety Certificate" of a vessel when such vessel exceeded the requirements imposed by Article VIII. The effect of this provision has already been referred to and need not be here enlarged upon.

As illustrating the meaning of the table in Article VIII, it may be stated, in general terms, that all vessels whose "factor of subdivision" is 0.5 or less are vessels any two of whose adjoining main transverse compartments may be flooded without resultant foundering of the vessel. This, of course, is for the vessel in the deeply laden condition and using the percentages of permeability referred to above. When the vessel is not loaded to the deep-load water line—as is most usually the case with passenger vessels—there is an additional "margin of safety" by reason of the correspondingly increased reserve of buoyancy. There is also an increase in the reserve of buoyancy as the "factor of subdivision" decreases in value.

As noted in paragraph 3 of Article VIII, two classes of vessels were considered by the conference, viz., "mixed cargo and passenger vessels" and "vessels primarily engaged in the transportation of passengers," the requirements being more stringent for the last-named class. For vessels whose service is such as to place them in a category between these two classes a "criterion of service" is authorized, the determination of which is provided for in Article 30 of the convention.

Article IX of the regulations gives in some detail additional requirements as to subdivision, especially as regards increase in floodable length of forward end of vessel, the maximum length of compartments, and restrictions as to recesses and steps in bulkheads.

PEAK AND MACHINERY BULKHEADS.

Article 18 of the convention and Article XI of the regulations establish requirements as to location of peak and machinery space bulkheads.

While the principal marine registration and classification societies already prescribe certain requirements for such bulkheads for vessels classed by them, the action of the conference makes these requirements obligatory for all new vessels covered by the convention whether "classed" or not. Provision is also made in Articles 19 of the convention and XII of the regulations for fitting fireproof bulkheads which will serve to retard the spread of fire; it is also specified that the distance between any two consecutive fireproof bulkheads shall not be greater than 40 meters, that recesses in these bulkheads shall be fireproof, and that openings shall be fitted with fireproof doors.

EXITS FROM WATER-TIGHT COMPARTMENTS.

Articles 20 of the convention and XIII of the regulations specifically provide that in all "passenger and crew spaces a practicable means of escape for the occupants shall be provided from each water-tight compartment"; also that "there shall be a means of escape for the crew from each engine room, shaft tunnel, and stokehold compartment independent of the water-tight doors."

CONSTRUCTION AND INITIAL TESTING OF WATER-TIGHT BULKHEADS.

As the strength and efficiency of the main transverse water-tight bulkheads are among the most important elements in the safety of a vessel when the compartments bounded by such bulkheads are damaged and in free communication with the sea, the convention makes definite provision for the construction and testing of such water-tight bulkheads. These requirements are set forth in Article XIV of the regulations. It is also specifically required that "no change may be made in the structure of the bulkheads after the completion of the survey (of the vessel) without the permission of the administration."

OPENINGS IN WATER-TIGHT BULKHEADS.

Rigid requirements as to the extent of water-tight subdivision and the character of construction of water-tight bulkheads would be of little avail unless severe restrictions were imposed upon the location and number of openings in such bulkheads, and, when such openings are permitted, the method of closing same. Articles 22 of the convention and 15 of the regulations set forth in considerable detail the restrictions with respect to such openings in water-tight bulkheads. It is stated specifically that "the number of openings in water-tight bulkheads shall be reduced to the minimum compatible with the design and proper working of the vessel," and that satisfactory means shall be provided for closing such openings as are permitted. It is also definitely provided that—

"No doors, sluice valves, manholes or access openings are permitted—
"(*a*) In the collision bulkhead below the margin line;
"(*b*) In water-tight transverse bulkheads dividing a cargo space from an adjoining cargo space or from a reserve bunker,"

except under unusual conditions, which are definitely set forth and limited. Not only are the types of water-tight doors prescribed, but the method of their operation and their location are subject to definite limitations. It is also prescribed that all water-tight doors shall be kept closed during the navigation of the vessel, except when necessarily opened for the working of the ship, and even in this contingency they shall always be ready to be immediately closed.

OPENINGS IN SHIP'S SIDE.

Recognizing the importance of limiting the number and defining the character of openings permissible in a vessel's side, Articles 23 of the convention and XVI of the regulations impose definite restrictions with respect to such openings. It is specifically required that "All inlets and discharges in the side shall be arranged so as to prevent any accidental admission of water into the vessel." It is also provided that side scuttles which are capable of

being opened and which are permitted in certain positions "shall be closed water-tight and locked before the vessel leaves port; they shall not be opened during navigation; the time of opening such scuttles in port and of closing them and locking them before the vessel leaves port shall be entered in the official log." Also, that the construction of such scuttles shall be such as to prevent any person opening them without the consent of the master. It also provides that the number of scuppers, sanitary discharges, and other openings in the sides shall be reduced to a minimum; also, that in no case shall gangway, cargo, and coaling ports be fitted below the load water line; also, that all cargo, gangway, and coaling ports in ship's side below the margin line shall be effectively closed and made secure before the vessel leaves port and kept closed during navigation.

CONSTRUCTION AND TESTS OF WATER-TIGHT DECKS, WATER-TIGHT DOORS, SIDE SCUTTLES, ETC.

The method of construction and character of tests applied to water-tight decks, doors, etc., were thoroughly considered, and Articles 24 of the convention and XVIII of the regulations require that the design and materials used in the construction of water-tight decks, water-tight doors, side scuttles, cargo and coaling ports, etc., and all tests of same shall be to the satisfaction of the administration of the country to which the vessel belongs. It is also provided that no change shall be made in the structure of water-tight decks, trunks and ventilators after the official survey of the vessel, except by permission of the proper Government officials.

PERIODICAL OPERATION AND INSPECTION OF WATER-TIGHT DOORS, ETC., AND ENTRIES IN OFFICIAL LOG.

One of the most important practical requirements of the convention in matters relating to the operation of ships relates to drills for the operating of water-tight doors, side scuttles, valves and closing mechanism of scuppers, ash chutes, etc. Articles 25 of the convention and XIX of the regulations prescribe that a complete drill of this character shall take place before leaving port, a second as soon as practicable after leaving port, and others thereafter at least once a week during the voyage. It is also provided that all water-tight power doors and hinged doors in main transverse bulkheads in use at sea shall be operated daily. Articles 26 of the convention and XX of the regulations require that entries shall be made in the official log book with respect to all drills and inspections and the closing of all hinged doors, portable plates, side scuttles, etc., and that a record shall be made in the official log of any defects discovered during inspection.

DOUBLE BOTTOMS.

Recognizing the importance of defining by international agreement the character and extent of double bottoms in vessels, Articles 27 of the convention and XXI of the regulations set forth in general terms the requirements in this respect. It will be noted that double bottoms are required for at least the forward portions of the vessel in all ships over 200 feet in length. For vessels over 300 feet in length, this double bottom is continuous from the forepeak bulkhead to the afterpeak bulkhead. Moreover, for ships more than 300 feet in length, it is required that the inner bottom shall be carried out to the ship's side in such manner as to protect the bilges. For ships more than 700 feet in length, the double bottom

for at least half the ship's length amidships and as far forward as the forepeak bulkhead shall extend up the ship's sides to a height above the top of the keel not less than 10 per cent of the ship's molded breadth.

The foregoing indicate the principal structural requirements prescribed in the International Convention on Safety of Life at Sea with a view to increasing safety of construction.

BACKING POWER AND AUXILIARY STEERING GEAR.

In Articles 28 of the convention and XXII and XXIII of the regulations it is specified that vessels shall have sufficient power for going astern to secure proper control of the ship under all circumstances; also that vessels shall be provided with an auxiliary steering apparatus.

INITIAL AND SUBSEQUENT SURVEYS.

Very important provisions of the convention are those which relate to the initial and subsequent surveys of vessels. Though necessarily general in terms, the specific provisions of Articles 29 of the convention and XXIV–XXVI of the regulations fix a high standard of requirements which must hereafter be met by the vessels of each signatory state.

The surveys required are as follows:

"(A) A survey before the vessel is put in service;
"(B) Periodical surveys once each year, and
"(C) Additional surveys as occasion arises."

It is required that these surveys be carried out as follows:

"(A) The survey before the vessel is put in service shall include a complete inspection of the hull, machinery, and equipments, including the outside of vessel's bottom, and the inside and outside of boilers.

"This survey shall be such as to insure that the arrangements, material, and scantlings of the hull, boilers and their appurtenances, main and auxiliary machinery, life-saving appliances and other equipments, fully comply with the requirements of this convention and of the detailed regulations promulgated by the Government of the contracting State to which the vessel belongs for vessels of the service for which it is intended. The survey shall also be such as to insure that the workmanship of all parts of the vessel and its equipments is in all respects satisfactory.

"(B) The periodical survey shall include an inspection of the whole of the hull, boilers, machinery, and equipments, including the outside of the vessel's bottom. The survey shall be such as to insure that the vessel, as regards the hull, boilers, and their appurtenances, main and auxiliary machinery, life-saving apparatus, and other equipments, is in satisfactory condition and fit for the service for which it is intended, and that it complies with the requirements of this convention and of the detailed regulations promulgated as a result thereof by the Government of the State to which the vessel belongs.

"(C) A survey, either general or partial, according to the circumstances, shall be made every time an accident occurs or a defect is discovered which affects the safety of the vessel or the efficiency or completeness of its life-saving appliances or other equipment, or any important renewals or repairs are made. The survey shall be such as to insure that the necessary repairs or renewals have been effectively made, that the material or workmanship of such repairs or renewals are in all respects satisfactory, and that the vessel complies in all respects with the provisions of this convention and of the detailed regulations promulgated as a result thereof by the Government of the State to which the vessel belongs."

QUESTIONS FOR FURTHER STUDY AND AGREEMENT.

In the course of the deliberations of the Committee on Safety of Construction questions arose which could not be fully considered at that time, as it would have involved extensive and prolonged investigations, mathematical calculations, and, in some instances, experiments. The convention definitely provided, however, for future undertakings of this character by individual States and for the free exchange of any definite results obtained. This provision for further research and a free interchange of information obtained is contained in Article 30 of the convention. It is a very important provision and when given full effect by the signatory States will undoubtedly produce excellent results.

SUMMARY.

It is not claimed that ideals have been attained; indeed, there is always room for improvement and progress. But a good beginning has been made and it is believed that the spirit shown by the representatives of the various countries participating in the conference affords ample evidence that there will follow, through the instrumentalities provided by the convention, still further developments in ship construction and arrangement which will increase the safety of travel at sea.

It is well to bear in mind, however, that there can never be absolute safety at sea any more than there can be complete security of travel by land. Even perfection of material, were such attainable, must be accompanied by vigilance of personnel and the exercise of careful and prudent seamanship. In fact, we may accept without reservation the absolute accuracy of the following paragraph from the summary of the work of the Committee on Safety of Construction, as given in the closing address of the president of the conference:

"In concluding this summary of the provisions on 'safety of construction' it is important to point out that, even after the most careful attention to all practicable details of design which increase the safety of a vessel at sea, there still remains the possibility of a serious and even totally destructive accident. Therefore, it is imperative that those charged with the management of vessels should never relax their vigilance on the supposition that any vessel is unsinkable. On the contrary, they should strive to add to the safety provided by the vessel itself that very great increase in safety which results from prudent and skillful management and navigation."

CHAPTER V.

RADIOTELEGRAPHY.

APPARATUS.

Wireless apparatus working at least 100 miles, day or night (Art. 35), is required on all vessels—steam, sail, motor, passenger, or cargo—having on board 50 or more persons (passengers or crew, or both) on ocean voyages in foreign trade or on voyages between the nations represented and their colonies (Art. 31). This range of apparatus and minimum

number of persons on board are the same as in the American law. The American law, however, applies only to steam vessels, while the requirement of the convention applies also to sail vessels or vessels propelled by other means than steam. Very few sail vessels have crews of 50 or more. The convention requirements cover vessels propelled by the Diesel engine or other forms of machinery not dependent on steam.

Under the American law (June 24, 1910, Sec. 2) steamers plying between ports or places less than 200 miles apart are exempt from the requirement to carry wireless apparatus. The convention makes no such general exemption. If, however, it can be shown to the Government (Art. 32) that the route and conditions of a voyage render the requirement of wireless apparatus unreasonable or unnecessary, vessels making such voyages may be exempted if they do not go more than 150 miles from the nearest coast, or if within tropical or semitropical waters (between the limits of 30° North latitude and 30° South latitude) they take on temporarily native cargo-hands, or stevedores, thus for the time increasing to over 50 the number of those on board. This custom obtains to a slight extent in the West Indies, but more generally on the coasts of Africa and Asia. In the same waters where native dhows or junks are used to an extent, a similar exemption on like conditions is permitted.

The only absolute exemptions from the requirement to carry the apparatus are in the obviously necessary cases where a master at sea picks up shipwrecked persons or where he is obliged to provide temporary substitutes for members of the crew who are ill or by direction of Government is required to transport certain persons such as distressed seamen who must be returned under the laws of most nations from foreign ports to their native land, and by any of these methods the usual number on board is increased above 50.

Every ship equipped with wireless apparatus is also required (Art. 35) to carry an emergency apparatus to be used in the event of the disabling of the ship's main dynamos on which the power for the wireless apparatus in many cases depends. In substance, this requirement is similar to the requirement of the American law for an auxiliary power supply. The convention requirements, however, are more precise. The emergency apparatus must be placed in its entirety in the upper part of the ship, as high as is practically possible in a position of the greatest possible safety to be determined by the Government, and must have an independent source of energy which may be put rapidly into operation. The convention requires that this apparatus must be capable of working for at least six hours. The American law requires a minimum of four hours. The convention requires a minimum range of 80 miles for larger vessels and 50 miles for smaller vessels. The American law requires a minimum range of 100 miles for the auxiliary apparatus on all vessels. In this respect the requirements of the convention are the same as those imposed by the London Radiotelegraphic Convention of 1912 on a limited number of larger vessels. The present American law is not in precise conformity with the Radiotelegraphic Convention. The differences, however, are not essential, as the longer period of operation at the lesser range about equals in efficiency the shorter period of operation at the longer range. As a practical matter the range of radio apparatus cannot be precisely determined, atmospheric conditions, the season of the year, and other factors exerting more or less influence on range. Most apparatus which covers 80 miles usually will also carry the signals to a distance of 100 miles or over.

The advantages of having the wireless apparatus entirely independent of the ship's main engines and dynamos connected therewith and of its installation on the highest part of the ship with its own power supply directly under the control of the operators are obvious.

Where such emergency apparatus is installed with a range of 100 nautical miles communication with the dynamos in the ship's engine-room is not required. This form of installation is somewhat more expensive than the usual installation but is of the most efficient type yet devised, and its use as the main wireless installation, rather than as an emergency installation, is thus encouraged by the convention.

OPERATORS.

The London Radiotelegraphic Convention of 1912, which has been ratified by the principal maritime powers, provides that every radio station on shipboard shall be in charge of a certificated operator able to transmit and receive messages at the rate of 20 words a minute (first grade) or 12 words a minute (second grade). The London Radiotelegraphic Convention of 1912 divided wireless stations on shipboard into three classes: First, those which maintain a constant service throughout the 24 hours; second, those which maintain a service during limited stated intervals of the day or night; and, third, those having no fixed hours of service. That convention provided that wireless stations on shipboard should be arranged according to these classes by the Governments concerned. This classification, however, had been suspended to await the action of the recent conference. At this conference nations differed as to the meaning of the classification, the American delegation holding that this former classification dealt with the commercial operations of wireless ship stations and that their use for purposes of safety at sea required a different arrangement. Representatives of certain other nations held that the London conference of 1912 had taken up the matter of safety at sea and that the present conference could only complete the work of classification outlined at the former conference.

The American delegation insisted on the principle of a continuous wireless watch on all ships by operators, aided, if necessary, by watchers not skilled in the transmission of messages. Several of the continental nations insisted that the better plan would be to maintain the continuous watch on a relatively smaller number of vessels and to provide these with skilled certificated operators. Article 34 of the convention represents a compromise between these divergent views. It lays down the principle that on all ships equipped with wireless apparatus the Governments respectively shall require a continuous watch to be maintained during navigation as soon as they consider that it will be of service for the purpose of safety of life at sea. The United States has already expressed itself in favor of the continuous watch for purposes of safety of life, and it is understood that at the time the convention takes effect the British Government will be prepared to take the same view. The German representatives expressed some doubt as to whether on less frequented routes, as along the west coast of Africa, a continuous watch could be effectively maintained, and Italian representatives doubted the need of it on short voyages on the frequented routes of the Adriatic, where ships may employ the ordinary means of communication by flags and lights. Pending the conclusions on such routes, which are mainly in waters not frequented by vessels over which the United States has control, the convention provides (Art. 33) for two first-grade operators on all ships with an average speed of 15 knots or more, carrying 25 or more passengers. This includes most trans-Atlantic and trans-Pacific passenger steamers in trade with the United States. A continuous watch is also required on ships of an average speed of more than 13 knots, having on board 200 persons or more, passengers and crew, making voyages of more than 500 miles between two consecutive ports. Trans-Atlantic or trans-Pacific passenger steamers in trade with the United States not included in the first group fall, with

few exceptions, into the second group. Finally all ships equipped with wireless apparatus are required to maintain a continuous watch when they are engaged in the trans-Atlantic trade or in other trades taking them more than 1,000 miles from the nearest coast, which of course covers the trans-Pacific voyages to the United States. To render possible the establishment of the continuous watch the convention provides that in addition to operators a new rating, called the certificated watcher, shall be established, the function of the watcher being to sit with the telephone on his ears and in cases of emergency summon the skilled operator who is usually berthed in a cabin opening into the radio room (Art. 34).

It was contended with much force that the task of sitting at an instrument with telephones on one's ears for long stretches when on unfrequented routes no messages are passing through the ether would be tiresome and the watch might be ineffective.

A mechanical device able to select the distress call from other calls and by a bell summon the operator would be more effective. Inventors have been endeavoring for several years to devise such an instrument, but thus far without success. Its invention, of course, will simplify the difficult problem of maintaining a continuous wireless watch on all ships.

The provisions in regard to operators and watchers will not apply in terms to some vessels in trade between the United States, the West Indies, Central America, and Mexico. Until July 1, 1915, however, such ships are subject to the American law which requires two men skilled in the use of the apparatus, and the convention (Art. 72) provides in substance that such compliance shall continue after the convention takes effect.

RULE OF ASSISTANCE.

The provisions in Artices 33 and 34 for a continuous wireless watch on all vessels equipped with radio apparatus, together with the requirement in Article 37 binding the master of every vessel to proceed to the assistance of a vessel in distress, constitute the broadest declaration every made by maritime nations in statutory form of the principle of the mutual obligation of those at sea to aid one another when in distress. In the case of cargo boats or small passenger vessels doing little commercial wireless business one operator evidently would suffice to send out distress calls in event of casualty imperiling those on board. If not on duty at the time, he could be promptly roused and send out his call almost instantly. The second operator or watcher in the case of such vessels, however, is prescribed in the interest of safety of those on board other vessels, and is thus, in effect, a tax upon the owners of cargo boats and passengers in the interest of the general safety of ocean navigation.

Every master of a vessel who receives a call for assistance from a ship in distress by Article 37 is bound to proceed to the assistance of the persons in distress. The Brussels convention of 1910, with respect to assistance and salvage at sea (Art. 11), provides that every master is bound, so far as he can do so without serious danger to his vessel and crew or passengers, to render assistance to everybody found at sea in danger of being lost. The Belgian delegation at London contended that this article obliged the master of a vessel hearing a wireless distress call to render assistance, but the French delegation, turning to the text of the Brussels convention, maintained that the words used, "trouvée en mer," could not have so broad a meaning, as it would do violence to their language to maintain that a ship 300 or 1,000 miles distant from a vessel in distress and hearing its call could in any proper sense be said to have "found" the vessel. These divergent views were harmonized in Article 37, which may be regarded either as affirming the Brussels declaration or as stating for the first

time the obligation of every master who receives a wireless call to come to the assistance of a vessel in distress. The wireless call reaches equally in all directions from the sending station, and accordingly all ships within a radius of 100 miles or more receive the call of distress, which must be immediately answered in accord with the London Radiotelegraphic Convention. These replies enable the master of the vessel in distress to learn the agencies to which he may look for assistance, and Article 37 of the convention enables him, if he wishes, to select from the vessels which answer the individual vessel or vessels which will be most serviceable to him. If this right is not exercised, of course all vessels are bound to bring aid, unless special circumstances justify some other course. The London conference also recommended, though it did not require, that the number of coast stations able to send weather messages to vessels at sea should be increased; that an international weather service should be established and that all sail and steam vessels in the foreign trade should be equipped with apparatus to hear time and weather signals, even if not required to carry sending wireless apparatus (recommendations 13 and 14, after protocol).

One and two years, respectively, are allowed by Article 38 for the installation of the apparatus and for the training and recruiting of the operators on the several classes of ships subject to radiotelegraph requirements. The conference, however, urged all Governments (recommendation 15) to reduce this time as much as possible. The experience of the United States in the enforcement of its laws concerning radio communication has demonstrated that reasonable time must be allowed to procure the apparatus and to educate the operators.

Chapter VI.

LIFE-SAVING APPLIANCES AND FIRE PROTECTION.

LIFEBOATS.

The convention recognizes that the length of the vessel is the principal factor in determining the number of lifeboats which may be carried (formerly the number of lifeboats was fixed by regulation according to the tonnage of the vessel). The length of the vessel fixes, of course, the number of sets of davits which may be set up and used simultaneously. (Art. 47.) Davits, of course, cannot be placed in the bows or near the stern. (Art. XLIV.) Article XLI then provides that each set of davits shall have a lifeboat of the first class attached to it. If these lifeboats attached to davits do not suffice for all on board, then more lifeboats must be provided (Art. XLII) at least up to a minimum fixed by Article XLIII. Article XLIII gives a table, showing for vessels of all lengths from 100 feet to 1,030 feet the minimum number of sets of davits and the minimum number of cubic feet in the accompanying number of lifeboats required. The table gives these requirements at intervals of from 15 to 35 feet in lengths, but the following at intervals of 100 feet will illustrate:

Length of vessel.	Number of sets davits.	Cubic feet in life-boats.
300 feet	8	7,550
400 feet	10	11,700
500 feet	14	17,310
600 feet	18	21,900
700 feet	22	28,560
800 feet	24	34,350
900 feet	28	41,000

Ten cubic feet per person (0.283 cubic meters) are provided in lifeboats (Art. XXXIV), so that the number of persons for whom there are lifeboats may be readily learned from the table. Thus, the lifeboats on a vessel 300 feet long must accommodate at least 755 persons, and on a vessel 900 feet long must accommodate 4,100.

So far as voyages from the United States are concerned, the requirements laid down in the table in Article XLIII do in fact require lifeboats for all those on board the steamers which carry passengers from the United States across the Atlantic to the ports of Europe. The exceptions are so rare as to demonstrate the general operation of the rule of the convention. Careful examination has been made of the returns of the 215 ocean steamships which carried over 12 passengers from ports of the United States across the Atlantic to ports in Europe during the calendar years 1912 and 1913. During the two years these steamships made 2,691 such voyages. Compliance with the requirements of the table already mentioned would have secured lifeboats for all on board during such voyages, except in the case of 33 voyages. The convention table, in other words, would have provided lifeboats for all in 99 voyages out of every 100 from the United States. These 33 voyages were made by 25 steamers, the same vessel rarely twice carrying a number of passengers, requiring the employment of the life-raft rule. These 33 exceptional voyages were (with the exception of single voyages of three first-class German steamships) voyages to the Mediterranean, and in three instances were Greek steamers, which, with Mediterranean ships of other nations, during the Balkan War carried many Greeks, Bulgarians, and others home to join their respective colors.

The vessels just considered and others (in all 242), during 1912 and 1913, made 2,956 trans-Atlantic voyages to the United States from the ports of Europe, where they were under the supervision of British, German, French, Italian, and other foreign authorities. On 359 of these 2,956 voyages the number of persons for whom lifeboats are provided by the table in Article XLIII of the convention is less than the total number who were actually on board, and in such cases (about 12 per cent of the total, mainly from Mediterranean ports) life rafts in addition would be required. The lifeboats, however, must provide for at least 75 per cent of those on board. In one typical case of an Italian steamer 1,960 persons were on board, of whom 75 per cent would be 1,470. The minimum lifeboat capacity required by the convention table for such a vessel is 1,306, so that under the convention the vessel would have been required to increase its lifeboats or reduce the number of passengers. In an-

other case of a German steamer 3,595 were on board, of whom 75 per cent is 2,692. The convention table prescribes lifeboats on a ship of the length in question (599 feet) for 2,190. Under the convention in this case the number of passengers would have to be reduced by 506 or additional lifeboats provided. As the possible number of sets of davits is limited by the length of the ship, and the possible number of lifeboats by deck area, and as the convention rules provide for so many davits and boats that any appreciable increase in either will be disadvantageous in other respects, the normal effect of the convention rule on the part of the 359 voyages mentioned will be to reduce the number of passengers carried, especially from Mediterranean ports, below the number permissible and actually carried during 1913.

In unusual cases where the vessel has accommodations for and desires to carry more persons than can be carried in the lifeboats under the rule for davits, already mentioned, based on the length of the ship, the convention allows the use of improved pontoon life rafts for not to exceed 25 per cent of the persons on board. (Art. XLII.) As indicated, the convention requires lifeboats for all in the case of practically every voyage from the United States, and the American delegation, as a whole, favored the general application of this rule to other trades. In the conference the sentiment in favor of the limited use of improved life rafts was fortified by the experience in October of the steamship Volturno, when the heavy sea running prevented for a time the successful use of lifeboats, and Capt. Inch set to work to build life rafts on board. The Committee on Life-saving Appliances, after thorough discussion, decided in favor of the limited optional use of life rafts by a vote of 11 to 2 (United States and Norway), the majority including experienced seamen like Capt. Charles, of the steamship Lusitania; Capt. Young, Capts. Polis and Schmalz, of Germany; Capt. Fragiacomo, of Austria-Hungary; Capt. Bultinck, of Belgium; and Capt. Veroggio, of Italy.

Arrangements must be such that as large a number as possible of boats and rafts may be launched on either side of the vessel. (Art. 48.)

Each boat must be strong enough to be lowered safely into the water with its full complement of persons and equipments. (Art. 42.) In determining the freeboard of pontoon boats each person is to be reckoned at 165 pounds (including life jacket) instead of 140 pounds, as at present. (Art. XXXVI.)

When rafts are carried, rope ladders must always be available for use (Art. 44.)

A limited number of motor boats may be used as lifeboats. (Art. XXVII.)

All boats and rafts must be so stowed that they can be launched in the shortest time even under unfavorable conditions of list and trim, so that it may be possible to embark the largest number of persons possible. (Art. 48.)

Davits shall be strong enough to lower fully loaded boats when the ship has a list of 15°. (Art. 49.)

Pontoon boats must be arranged so that 2 tons of water may be cleared within 60 seconds or less. (Art. XXXI.)

Wooden pontoon lifeboats must have the bottom and deck in two thicknesses of wood with textile material between. (Art. XXXII.)

Pontoon rafts must be such that they can be handled without mechanical appliances and, if necessary, be thrown from the vessel's deck; they must be reversible, with bulwarks on both sides, and provided with at least 3 cubic feet of air cases or equivalent buoyancy for each person. (Art. XXXIII.)

Seating accommodations must be provided for all carried on pontoon boats and rafts without interfering with the use of oars. (Art. XXXV.)

Detailed equipment for lifeboats and life rafts is provided in Article XL. Details of types of construction and measurement of lifeboats and rafts are provided in Articles XXVIII, XXIX, XXX, XXXI, XXXII, XXXIII, XXXIV, XXXV, XXXVI, XXXVII, XXXVIII.

APPLICATION AND EXCEPTIONS.

Under the chapter on life-saving appliances and fire protection new vessels are defined (Art. 39) as those of which the keel is laid after December 31, 1914, and all other vessels are considered existing vessels. The convention is to take effect on July 1, 1915 (Art. 69), but each Government undertakes to enforce all the chapter on life-saving appliances on existing vessels "as soon as possible and not later than the 1st of July, 1915" (Art. 52). Exception may be made, however, in the following requirements if a strict application "would not be practicable or reasonable" (Art. 52):

Art. XLVI. (*a*) The types of boats and rafts now approved by governments may be accepted in lieu of the convention types, and (*b*) the double thickness of bottom and deck and the new freeboard of pontoon boats may not be required. (*c*) In vessels between 245 and 460 feet one less set of davits and in vessels over 460 feet one less set of davits on each side may be allowed "only, if proper provision is made for launching the boats."

That some time should be allowed to make the necessary changes was generally conceded, but the time limit was extended to January 1, 1920, by a vote of 8 to 5. The American delegation opposed so long an extension, as did the British.

The provisions that each pair of davits shall be strong enough to lower a fully loaded lifeboat when the ship has a list of 15 degrees, and that every boat must be strong enough to be lowered fully loaded, are not compulsorily applicable on all existing vessels.

LIFE JACKETS AND LIFE BUOYS.

Life jackets for all on board, and an additional supply of smaller sizes for children, are required by Article 51. The same article requires a supply of life buoys, the number and particulars of which are prescribed in Article XLV. For at least half of the life buoys self-igniting lights which cannot be extinguished in water must be ready at hand.

EMERGENCY LIGHTING.

Special provision is made by Article 53 for the lighting of decks and compartments in case of accidents disabling the ship's main lighting plant. Provision must be made for lighting the different parts of vessels, particularly the boat deck, and on new vessels an emergency lighting plant must be installed as high as possible in the upper parts of the vessel. This emergency lighting system will probably be installed in connection with the emergency wireless system. The same article requires the exit from every compartment to be lighted by an emergency lamp, independent of the regular lighting plant.

SUFFICIENT AND EFFICIENT CREWS.

The convention lays upon the nations the following obligation in Article 15:

"Art. 15. The Governments of the High Contracting Parties undertake to maintain, or, if it is necessary, to adopt measures for the purpose of insuring that, from the point of view of safety of life at sea, vessels defined in Article 2 shall be sufficiently and efficiently manned."

This article is identical in substance (so far as passenger ships in question are concerned) with the following rule laid down by the United States Circuit Court of Appeals, ninth circuit, May 2, 1904, *In re* Pacific Mail Steamship Co. (130 Fed. Rep., 82):

"There can, in our opinion, be no doubt that the crew of a ship must be not only sufficient in numbers, but also competent for the duties it may be called upon to perform."

In its relations to the entire convention Article 15 coincides even more closely with the rule laid down *In re* Meyer (74 Fed., 885), quoted in the case just mentioned:

"It is the duty of the owners of a steamer carrying goods and passengers not only to provide a seaworthy vessel, but they must also provide the vessel with a crew adequate in number and competent for their duty with reference to all the exigencies of the intended route and with a competent and skillful master of sound judgment and discretion, etc."

The rule of the courts may be invoked in the determination of damages after loss has been incurred; the provisions of Article 15 of the convention, enforced through Article 65, aim directly to prevent conditions which may lead to loss. Article 15 prescribes that from the point of view of safety of life at sea vessels under the rules of the convention must carry crews in all departments, the engine room, fire room, and the steward's department, as well as the deck department, sufficient in numbers and efficient in the various duties they may be called upon to perform, and this requirement applies to the officers, who are all (except the captain) included in the crew. The principal duties in connection with safety (apart from those connected with the navigation of the vessel now performed on deck by the deck officers, quartermasters, or wheelmen and lookouts, and below by the engineers) are set forth in Article 56, and Articles XIX, XX, L, and LI. Article 64 of the convention binds the contracting States to communicate mutually information which they possess so far as manning on their own vessels for the purposes of safety is concerned as well as information concerning construction and appliances. The interchange of such information is clearly for the advantage of those who travel by sea.

CERTIFICATED LIFEBOAT MEN.

The convention aims to prevent disasters, particularly by messages to navigators of impending sources of danger and by intercommunication between ships; if, however, a disaster should occur, the convention next aims to provide for a ship which will keep afloat the longest possible time until it can reach port or until assistance may arrive. It then provides for the general use of radiotelegraphy to enable the largest number of vessels practicable to render assistance to a ship in distress, whether from external cause (collision, typhoon, etc.) or internal cause (breaking of shafts or loss of propellers in storms, fire, etc.). Abandon-

ment of the ship was recognized by the conference as the last resort and under modern conditions of navigation, which the convention aims to improve, the occasions will be rare when all on board a ship must leave it with no other ship near enough to offer prompt assistance. Even on such rare occasions, storm or high waves sometimes, of course, render the successful launching of loaded lifeboats from high decks impossible.

When all on board the ship must leave, the convention recognizes that the work of the entire crew is transferred from the ship to the lifeboats, and in some cases, as already indicated, to life rafts. The preparations which must be made for emergencies are stated in Articles 54 and 56 and Articles XLVII and XLVIII. There must be, under Article 54, for each boat or raft required a minimum number of certificated lifeboat men, not less than three for each lifeboat or life raft. (Article XLVII.) The certificated lifeboat man, by Article 54, is "Any member of the crew who holds a certificate of efficiency issued under the authority of the administration concerned in accordance with Article XLVII." Article XLVII provides that to obtain a lifeboat man's certificate—

"the applicant must prove that he has been trained in all the operations connected with launching lifeboats and the use of oars; that he is acquainted with the practical handling of the boats themselves; and, further, that he is capable of understanding and answering the orders relative to lifeboat service.

"There shall be for each boat or raft a number of lifeboat men at least equal to that specified in the following table:

"If the boat or raft carries—	The minimum number of certificated lifeboat men shall be—
Less than 61 persons	3
From 61 to 85 persons	4
From 86 to 110 persons	5
From 111 to 160 persons	6
From 161 to 210 persons	7

and, thereafter, one additional certificated lifeboat man for each additional 50 persons."

MEASURES AGAINST FIRE.

The provisions against fire are found in Articles 19 and 55 of the convention and Articles XII, XLIX, L, and LI of the Regulations.

To prevent fire Article 55 (1) prohibits the carriage either as cargo or ballast of goods which by reason of their nature, quantity, or mode of storage are, either singly or collectively, likely to endanger the lives of passengers or the safety of the vessel.

The division of the ship below the bulkhead deck into watertight compartments is considered in another place. These watertight bulkheads, of course, secure protection against the spread of fire below the margin line. Above the margin line fireproof bulkheads are required by Article XII. Further to check the spread of fire a continuous patrol system is prescribed by Article XLIX for the prompt detection of fire. The apparatus for extinguishing fire is described in Article XLIX, and fire musters and drills are required by Articles L and LI.

Chapter VII.

SAFETY CERTIFICATES.

The convention provides in Article 57 for an inspection and survey of every vessel subject to the convention to determine that it complies in an efficient manner with convention requirements. "In every case the Government concerned fully guarantees the completeness and efficiency of the inspection and survey." (Art. 57.) This obligation will involve an increase in the inspection force of the United States in view of the requirements of the convention, some of which are not provided for by the laws of the United States.

As testimony that a vessel has thus been found by inspection and survey to comply with convention requirements, the Government concerned issues to it a certificate called "Safety Certificate," and "the State to which the vessel belongs assumes full responsibility for the certificate." The certificate is not valid for a longer period than one year (Art. 59) and another inspection and survey are necessary before the issue of another safety certificate. Inspection and survey at least annually are thus prescribed, and by Article XXV further surveys are required "every time an accident occurs or a defect is discovered which affects the safety of the vessel or the efficiency or completeness of its life-saving appliances or other equipment, or any important repairs or renewals to be made." The Safety Certificate "shall be regarded by the Governments of other contracting States as having the same force as the certificates issued by them to their own vessels." (Art. 60.) This provision and, in fact, the convention, is a declaration by the nations accepting it that they are prepared to trust one another to carry out engagements, mutually agreed upon, in the matter of safety of life upon the sea, which is the common property of nations and over which no one nation exercises exclusive domination.

The spirit of this declaration is not new to the laws of the United States. The act of February 15, 1902 (32 Stats., 35), provides that when—

> "foreign passenger steamers belonging to countries having inspection laws approximating those of the United States and have unexpired certificates of inspection issued by the proper authorities in the respective countries to which they belong, they shall be subject to no other inspection than necessary to satisfy the local inspectors that the condition of the vessel, her boilers and life-saving equipments are as stated in the current certificate of inspection, but no such certificate of inspection shall be accepted as evidence of lawful inspection except when presented by steam vessels of other countries which have by their laws accorded to the steam vessels of the United States visiting such countries the privilege accorded herein to the steam vessels of such countries visiting the United States."

Under this statute arrangements for the mutual recognition of inspection certificates have been entered into during the past ten years between the United States on the one side and on the other Denmark, France, Germany, Great Britain, Canada, New Zealand, and New South Wales, Japan, Norway, and the Netherlands.

Germany and France have always held that the flag carries with it full control over the ship which flies it—even in foreign ports—by the Government to which the ship belongs. The United States and Great Britain have held the contrary theory that a foreign ship in one of their ports is subject to the jurisdiction of the Government of the port. The conflict between these two theories is sharp, and for a time at the conference it seemed impossible to reconcile them. The matter was referred to the American and German delega-

tions to effect, if possible, a compromise. These delegations after several meetings agreed upon Article 61, which was adopted by the conference. It reads:

"Every vessel holding a Safety Certificate issued by the officers of the contracting State to which it belongs, or by persons duly authorized by that State, is subject in the ports of the other contracting States to control by officers duly authorized by their Governments in so far as this control is directed toward verifying that there is on board a valid Safety Certificate, and if necessary that the conditions of the vessel's seaworthiness correspond substantially with the particulars of that certificate; that is to say, so that the vessel can proceed to sea without danger to the passengers and the crew."

The right of necessary inspection is affirmed. The principle of this article is essential to prevent the unnecessary duplication of inspections here and abroad. Such unnecessary duplication of inspections involves heavy expense to each government in the maintenance of an additional inspection force, when already in the United States and possibly in other countries the inspection force is not large enough to perform its necessary duties. Such unnecessary duplication of inspections puts obstacles in the way of and causes delay to international trade, which are not merely in themselves expensive to all those concerned in the mutual promotion of exports and imports between countries, but are the frequent and fruitful source of friction between governments and irritation between nations.

So far as treaties, conventions, and arrangements relating to safety of life at sea have already been entered into by nations covering vessels excepted from the convention, such agreements will continue to have full and complete effect by Article 68. Our present steamboat-inspection arrangement with Canada concerning vessels on the Great Lakes is of this nature. The convention, of course, does not affect prior treaties, conventions, and arrangements relating to matters not provided for in the convention, but relating to vessels (Article 68).

Attached to this report are copies of the proceedings of the plenary sessions of the conference and of the committees on safety of navigation, safety of construction, wireless telegraphy, life-saving appliances, and certificates—in all equivalent to a quarto volume of about 500 pages.

Respectfully submitted on behalf of the United States commissioners.

J. W. Alexander,
Chairman.

INTERNATIONAL CONFERENCE ON SAFETY OF LIFE AT SEA.

[Memorandum for the President.]

DEPARTMENT OF COMMERCE,
BUREAU OF NAVIGATION,
Washington, February 23, 1914.

The International Conference on Safety of Life at Sea was called by the British Government partly as a sequence of the desire among various nations to secure uniformity in maritime regulations of merchant shipping in international trade, but chiefly in consequence of the loss of the steamship Titanic on April 15, 1912. The maritime world generally was impressed by that catastrophe with the need of international action. This opinion found its first official expression in the joint resolution offered on April 17, 1912, in the House of Representatives by the Hon. J. W. Alexander, of Missouri, proposing an international maritime conference.

The resolution was approved by the President on June 28, 1912. In the meantime the subject of an international conference was under formal consideration by the British and German Governments. On April 24 the German Ambassador at Washington advised the State Department that the German Emperor proposed an international conference. After some discussion through diplomatic channels it was finally agreed that the initiative in calling the conference should be taken by the British Government.

On the invitation of the British Government accredited representatives of the following maritime nations met at the Foreign Office in London on November 12, 1913, at 11.30 a.m.: Austria-Hungary, Belgium, Denmark, France, Germany, Great Britain, Italy, Japan (not present at first two sessions), Netherlands, Norway, Spain, Sweden, Russia, United States of America, and of the following British self-governing Dominions: Australia, Canada, and New Zealand, in all 17 delegations, Austria and Hungary being represented, however, each independently, as well as through a representative of the Empire of Austria-Hungary.

The conference consisted of 96 delegates and technical advisers, and of 18 secretaries, of whom several were trained mariners.

The membership of the conference included 34 government officers engaged in administering laws and regulations relating to the navigation, construction, equipment, inspection, officers and crews of merchant vessels; 17 shipbuilders, naval and marine architects and principal surveyors and engineers of classification societies; 17 Members of Congress or foreign parliaments, diplomats, and admiralty lawyers; 10 shipowners; 6 experts in radiotelegraphy; 3 hydrographers and meteorologists; 4 naval officers not classified above; and 5 of other occupations, including the heads of the American and British seamen's unions. Of the total number, 31 to our knowledge were trained to seamanship from youth and have followed the sea for many years, some being called directly from sea duty, like Capt. Charles, of the steamship Lusitania, to take part in the conference, thence returning to sea. Probably 40 members of the conference at one time or another had followed or now follow the sea as an occupation, and there were few, if any, of the delegates without a knowledge from observation and experience of the conditions and requirements of modern ocean steam navigation.

The conference assembled at noon on November 12, 1913, and adjourned *sine die* at 6 p.m. on January 20, 1914, a period of 70 days. Work, however, was partially suspended during the Christmas holidays from December 20 to January 4, inclusive, although during this period the first draft of the convention was prepared, the Committee on Construction continued its labors, and some members of the American delegation were engaged on work connected with the conference.

The conference held four plenary sessions, the opening session on November 12 and a session on November 13 for the organization of committees. It did not meet again in plenary session until January 19, when the convention in its completed form was unanimously adopted and on January 20 signed by all delegates vested with full powers by their respective governments.

Six committees were appointed on November 13, and work was begun on the following day. These six committees held 123 sessions, as follows:

Committee on safety of navigation, 9; committee on construction, 51 (divided into subcommittees as follows: Full committee, 15; general principles, 3; subdivision of hulls, 11; strength of bulkheads, etc., 12; survey of passenger steamers, 10); committee on certificates, 12; committee on radiotelegraphy, 15; committee on life-saving appliances, 18; committee on revision, 10. In addition to these regular committees Lord Mersey, as president of the conference, organized informally a committee to prepare general articles for the convention, not within the jurisdiction of any regular committee, and to arrange for the coordination of committee work. This informal committee held 8 meetings.

The original purpose was to organize comparatively small committees to make early reports to the full conference, but it developed at the outset that each of the 17 States present desired representation on each committee as far as the number of its delegates would permit, and the committees thus from the beginning became small conferences at which each nation was represented by those of its delegates best able to speak with authority on the subjects before that committee. On the committee on certificates (Dr. von Koerner, Germany, chairman) 17 States were represented by 30 delegates and 3 secretaries, the American members being Judge Alexander and Mr. Chamberlain; on the committee on construction (Rear-Admiral Capps, United States Navy, United States, chairman), 14 States were represented by 30 delegates and 3 secretaries, the other American members being Messrs. Ferguson and Smith and Mr. McBride, technical adviser; on the committee on life-saving appliances (Sir John Harvard Biles, Great Britain, chairman) 15 States were represented by 34 delegates and 2 secretaries, the American members being Gen. Uhler and Capt. Bullard (Note: Mr. Furuseth was on this committee until he left London); on the committee on radiotelegraphy (Mr. Moggridge, Great Britain, chairman) 14 States by 25 delegates and 2 secretaries, the American members being Captain Bullard and Mr. Chamberlain; and on the committee on safety of navigation (Sir Norman Hill, Great Britain, chairman) 14 States by 29 delegates and 2 secretaries, the American members being Captain Cooper and Captain Commandant Bertholf. The committee on revision (Monsieur Guernier, France, chairman) originally consisted of 7 members from 6 nations, Judge Alexander representing the United States, but as its work was extended to prepare a complete revision of the entire convention for submission to the full conference its membership was increased to give each nation a representative on the committee. Lord Mersey's informal committee comprised the chairmen of the 6 committees and Dr. Seeliger of Germany, Judge Alexander and Mr. Chamberlain of the United States.

Each country had one vote in the conference and one vote in each committee, without regard to numerical representation. The American delegation held 16 meetings in London, at which the important propositions before committees were discussed and ample opportunity afforded to each commissioner to express his opinions. After full discussion, the delegation then voted on the position which the United States should take as a nation. In most instances the American delegation was unanimous. In no instance did the minority exceed three, and it seldom exceeded one or two. The conclusions thus reached as a rule were loyally sustained by the entire delegation. Other national delegations, of course, held similar meetings.

The scope of the work of the conference was, in effect, outlined in the Alexander resolution of April 17, 1912. The British list of questions before the conference was mainly a statement in detail of the broad subjects covered by the resolution of Congress. Only one material addition was made, that presented by the American delegation at the outset, at the instance of Secretary Redfield, that the subject of prevention and detection of fire on shipboard be included in the scope of the conference. The conference confined its discussions and conclusions, except in a few matters, to ocean passenger steamships. While there was some sentiment in favor of general action concerning cargo boats, it was decided at the outset that this extension of the conference work would unduly prolong the conference, and subsequent events justified this decision.

Deaths, 1914

WILSON BROWN

THOMAS DOLAN

Thomas Dolan was born in Montgomery County, Pennsylvania, October 27, 1834, and died at Torresdale, Philadelphia, June 12, 1914. He received his education in the public schools of Montgomery County, which he attended until fifteen years of age, when he secured a position in a retail dry goods store in Philadelphia, where he remained until 1856. He then formed a connection with a large importing commission house which handled English hosiery and Germantown knit goods, in which he built up a large business for his firm.

The depression in business following the outbreak of the Civil War led to the failure of the firm, and Mr. Dolan thus lost his position. In May, 1861, he arranged with one of the creditors of his former employers to rent a small, but completely equipped mill which had been left on their hands, agreeing to purchase the property at the end of the year. The new enterprise was established under the name of the Keystone Knitting Mills. Despite the precarious state of trade the business was trebled in three years. In 1872 Mr. Dolan installed in his mill machinery for the manufacture of coating worsteds, which was continued until 1897 under the firm name of Thomas Dolan & Company, becoming one of the most important manufacturing enterprises of the city of Philadelphia, with four thousand employees.

Mr. Dolan was one of the organizers of the Brush Electric Companies of Philadelphia, New York and Baltimore, and the first to install an electric plant in a factory. He and his associates were the pioneers in the introduction of electricity for street lighting purposes.

On February 26, 1892, Mr. Dolan was elected president of The United Gas Improvement Company, and during his presidency the lease of the Philadelphia Gas Works was effected, in 1897. Under municipal management the

works had for several years shown an annual deficit of about $400,000. Under the management of The United Gas Improvement Company the city receives in free gas for street lighting and public buildings, in extensions and betterments of plant (which will revert to the city at the termination of the lease), and in cash (a proportion of the receipts from the sale of gas) a rental equivalent to about $3,000,000 per annum.

Mr. Dolan was at one time president of the National Association of Manufacturers and was one of the organizers and the first president of the Manufacturers' Club of Philadelphia. He was one of the first members of the Union League and a vice-president for several years. At the date of his death, June 12, 1914, he was chairman of the Board of Directors of The United Gas Improvement Company, a director of the Fidelity Trust Company, the Finance Company of Pennsylvania, Philadelphia Electric Company, and a trustee of the School of Industrial Art.

WILLIAM R. ECKART

The death of William R. Eckart, which took place at Palo Alto, California, on December 8, 1914, after a lingering illness, closed a very successful engineering career covering a period of fifty years' practice on the Pacific Coast, during which period he did much for the development of the resources of the State he had made his home.

Mr. Eckart was born in Chillicothe, Ohio, June 17, 1841. In 1842 his family moved to Cleveland, where his father had large shipping interests on the Great Lakes. From the time he was twelve years old his school days were divided between the public schools of Chillicothe and Cleveland. Later he took a special course in mathematics at the St. Clair Academy, Cleveland.

In the early fifties his father removed to Zanesville to engage in the operation of a flour mill operated by water power. After working on the installation of some improved water wheels, Mr. Eckart got the opportunity to serve as an apprentice in the works of Griffith, Ebert, & Widge, which had a high reputation in those days for general mill and steamboat work.

During this apprenticeship he was fortunate in having the friendship and guidance of Mr. Widge, who had been at one time a foreman in the famous works of Joseph Whitworth, Manchester, England. Mr. Widge found the way and the time to teach him how to improve on his work after he himself had thought it "good enough."

In June, 1861, he took an examination before the Naval Board of En-

gineers and on July 30, when he was twenty years of age, he was appointed third assistant engineer in the navy and was ordered at once to join the fleet on the Pacific coast.

On July 10, 1864, Mr. Eckart resigned from the navy on account of poor health and went to San Francisco where he began work in the drawing room of H. J. Booth & Company; there he made the design and drawings for the first California built locomotive. He remained with this company until 1869, when he received an appointment as draughtsman in the steam engineering department at Mare Island Navy Yard. He was soon after made foreman machinist and later was promoted to superintendent of steam machinery through B. F. Isherwood, and while in this position he carried out under him a series of experiments on propeller efficiency that attracted considerable attention both in the United States and Great Britain.

In 1871 he left the Mare Island Navy Yard to go into partnership with Prescott and Schiedel at the Marysville Foundry; the firm name was later changed to Booth and Eckart. While there he contracted for and built the Steamer Meteor for the Carson Lumber Company; she had a guaranteed speed of 21 miles per hour, which she easily made on Lake Tahoe where she was used, and was probably the fastest boat of her size known at that date.

In 1876 he was recalled to San Francisco by Prescott, Scott and Company, successors to H. J. Booth & Company, to superintend the construction and assist in designing and erecting some heavy pumping machinery for the Comstock mines; soon after this he moved to Virginia City to become consulting engineer to the Bonanza firm that owned or controlled nearly all of the "North End" mines. In 1878 he was appointed U. S. Deputy Mineral Surveyor for the State of Nevada. While at Virginia City he designed and built, in connection with W. I. Sakeld, a noted millwright of that time, the Bullwer Standard Mill at Bodie, the largest pan mill for working ore that had been built up to that time.

In 1880 he was appointed a member of the U. S. Geological Survey under Clarence King to investigate and report upon the mechanical appliances of the Comstock lode. On this work, which was really a labor of love, he spent nearly two years collecting data, testing pumps, engines and hoists, and making drawings for the Government of all the machinery on the Comstock. The finest instruments procurable in the United States and Europe were used in this work.

In 1882 Mr. Eckart returned to San Francisco as a consulting and constructing engineer, and during the following eight or ten years some of the largest and most important mining plants were designed and constructed under his supervision.

In 1883, the Union Iron Works, formerly Prescott, Scott & Company, was changed to an incorporated company, and Mr. Eckart was retained as consulting engineer in matters pertaining to the propelling power of the government vessels built by that company. He was present at and assisted in conducting nearly all the preliminary and government trials of these vessels.

In 1889 he was appointed consulting engineer to the Standard Electric Company and later became the resident construction engineer for all their hydraulic works, including storage reservoirs, ditches, dams, flumes, pipe lines, and power-house installations. This was the first or among the first of the long-distance, high-potential transmission hydraulic plants projected.

Mr. Eckart was a member of the American Society of Civil Engineers, a member and past vice-President of the American Society of Mechanical Engineers, a member of The Society of Naval Architects and Marine Engineers, a member of the Institute of Mechanical Engineers, London, and an associate member of the Institute of Naval Architects, London.

GEORGE N. GARDINER

Mr. George N. Gardiner, who died on July 6, 1914, was born in New York City in 1844, and was a graduate of the New York University and a member of Zeta Psi Fraternity.

From the time of his graduation he devoted his energies to the development of coatings for the protection of ships' bottoms. He was the first manufacturer in this country of copper paints for the bottoms of wooden ships, and later perfected the "American McInnes Compositions" for the bottoms of steel and iron ships, which were largely used by the United States Navy and mercantile marine. Mr. Gardiner was, for fourteen years, expert for the navy on paints, his connection having commenced in the term of the late Secretary of the Navy, Gideon Wells. He was recognized as an authority on paints, and lectured before the engineering class of the Massachusetts Institute of Technology.

Mr. Gardiner was founder and senior member of the firm of George N. Gardiner & Son, president of the Gardiner Paint Company, and formerly a director of the Old Union Ferry Company of New York and Brooklyn. He was, for many years, a member of the New York Chamber of Commerce, the Colonial Club, the Rockaway Hunt Club, the Democratic Club of New York, Sons of the Revolution, and the Society of the War of 1812.

Mr. Gardiner was always greatly interested in church work, was for many years a warden of Zion Church in New York, and later was first treasurer of the Cathedral of the Incarnation at Garden City, and devoted much of his time to charitable work. He was a member of the 22d Regiment, and volunteered for service in the Civil War, in which he was breveted second lieutenant for conspicuous bravery. During the last few years of his life he made his home at Ardsley-on-Hudson, New York.

CAPTAIN RICHARD HENDERSON

U. S. NAVY, RETIRED

On February 24, 1914, there passed away, at Salisbury, North Carolina, Captain Richard Henderson, U. S. Navy (retired), one of the most talented and popular officers of the navy, a man whose influence on the younger officers during his period of active service, was most helpful and far-reaching.

Captain Henderson was born in Salisbury, North Carolina, August 23, 1855. Appointed cadet midshipman September 26, 1872, and graduated from the United States Naval Academy June 20, 1876; he was promoted to the grade of ensign July 1, 1878. He became lieutenant (junior grade) May 13, 1886, and lieutenant November 5, 1891. On September 9, 1899, he was promoted to lieutenant-commander, and to commander on June 21, 1905. He was transferred to the retired list of officers of the navy with the rank of captain from the 30th day of June, 1905, in accordance with the provisions of Section 8 of an Act of Congress approved March 3, 1899.

He had eighteen years and two months of sea service and eleven years and one month shore duty. He served on the Essex, Nipsic, Shenandoah, at the Torpedo Station, as assistant lighthouse inspector and as inspector of ordnance, Navy Yord, Washington, D. C.; on the Alliance, Asiatic Station; on duty at A. & M. College, Raleigh, N. C., January 6, 1894, to December, 1895; on the Indiana 1895 to 1899; as executive officer of that ship in the Battle of Santiago, July 3, 1898, during the war with Spain; served as a member of the Board of Inspection and Survey, and as executive officer on the Illinois and the Alabama, his last sea duty.

It may truly be said that Captain Henderson's life was one of unselfish devotion to duty, without fear and without reproach. He was kind and sincere in all his official and family relations, possessed good judgment and ability, and was an ideal officer. He is survived by a widow, two sons and a brother.

GILBERT N. McMILLAN

Gilbert N. McMillan died on October 17, 1914, after a short illness.

He was born in Detroit July 25, 1868, the son of Hugh McMillan and Ellen Dyar McMillan.

He was educated in the Detroit schools, also at Cornwall on the Hudson, the Princeton Preparatory School, and at Princeton University, from which he graduated in 1890.

Returning to Detroit he became connected with the Detroit Shipbuilding Company and was associated with it as secretary and treasurer until its consolidation with the other lake shipyards. Later he held the same position for a year with the Eastern Shipbuilding Company in New London, Connecticut. On his resignation from that position he retired from active business.

He was deeply interested in Good Roads and was the first to interest people in that movement in Pinehurst, North Carolina, where he lived a number of winters, moving from there to Cambridge, Massachusetts.

He was a member of the Yondotega Club in Detroit, the Detroit Boat Club, the Princeton Clubs of New York and Boston, the Ivy Club of Princeton, and of the Society of Naval Architects and Marine Engineers.

He is survived by a wife and three children.

NAOJI TOMIKAWA

Mr. N. Tomikawa was born on the 21st of April, 1874, in the town of Tochio, province of Yechigo, Prefecture of Nilgata. After the usual course of preparatory study he entered the Imperial University of Tokyo, Japan, and was graduated from the shipbuilding department of that University in July, 1898. Immediately thereafter he took service in the Mitsu Bishi Dockyard & Engine Works, Nagasaki. In January, 1901, he went abroad for further study, principally in England and Scotland, and remained there about five years. He returned to Japan in September, 1906, and again entered the service of the Mitsu Bishi Dockyard & Engine Works, Kobe, where he was chief draughtsman until June, 1910, when he resigned his position on account of ill-health. Although every effort was made he appears never to have recovered his health entirely and died on August 1, 1914, at the very time of life when his professional learning and abilities would have indicated a most successful future career.

JAMES G. WINSHIP

James G. Winship was born January 18, 1839, at New York City. He was the son of Ebenezer Winship, who for more than fifty years was connected with the famous Allaire Works of New York, most of the time as foreman and superintendent. The son inherited his father's love for the work and served his apprenticeship under him in the Allaire Works.

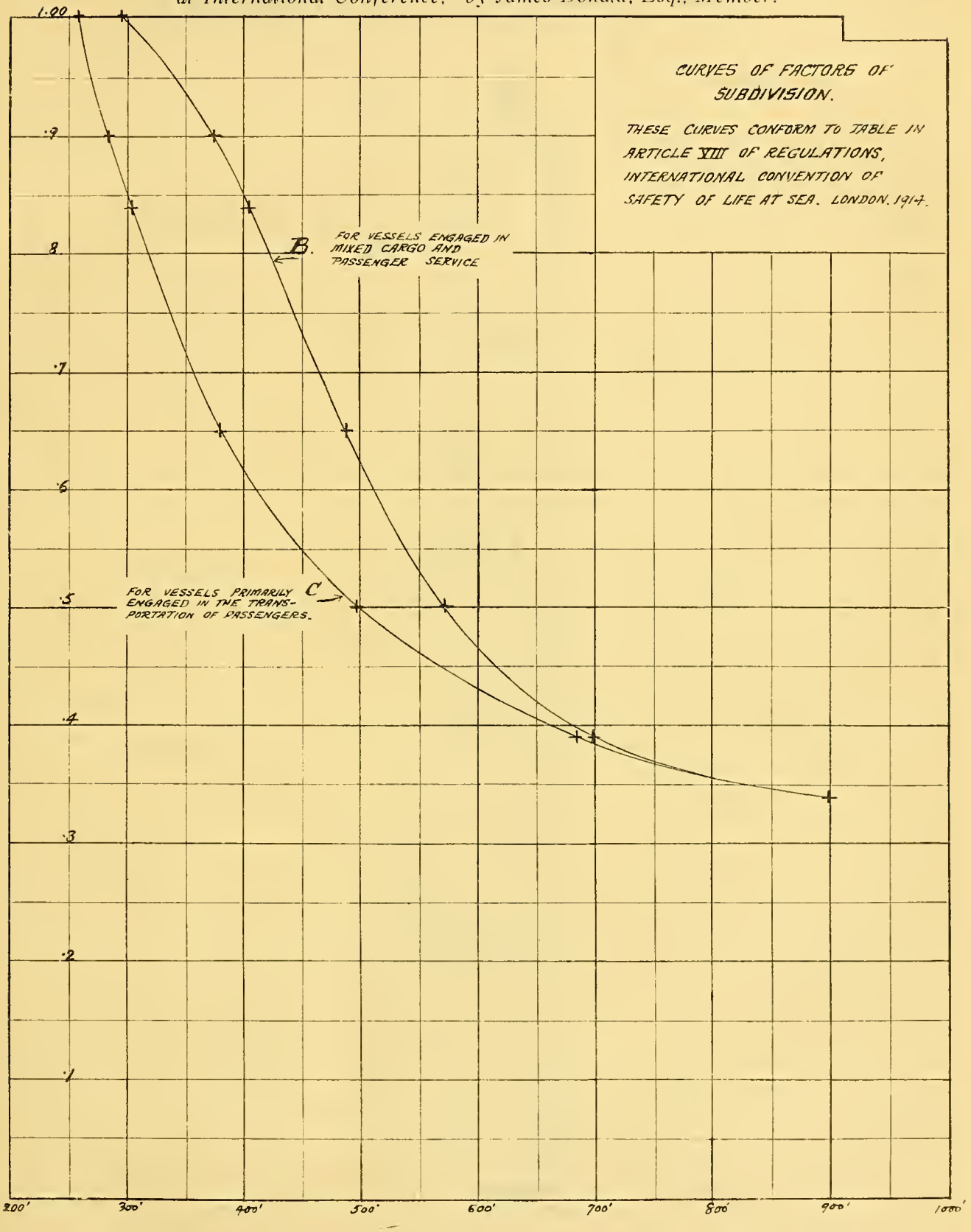
Reaching his majority just before the outbreak of the Civil War, he served in the engine-room of transports engaged in carrying troops and supplies to southern points, and afterwards became chief engineer of the Morro Castle, one of the finest steamers of the time out of New York, engaged in the trade with Cuba.

When about thirty-three years of age, he left the sea and entered the employ of the Blake Steam Pump Works, and remained with them after they became part of the International Steam Pump Company. Altogether he served over forty-three years with these companies.

During the earlier part of his service with them, he spent much time traveling, but during the latter years of his life he was a part of the city selling force, and had a wide acquaintance among the trade.

PLATES

To illustrate paper on "Safety of Life at Sea. Application of Subdivision Rules Adopted at International Conference," by James Donald, Esq., Member.



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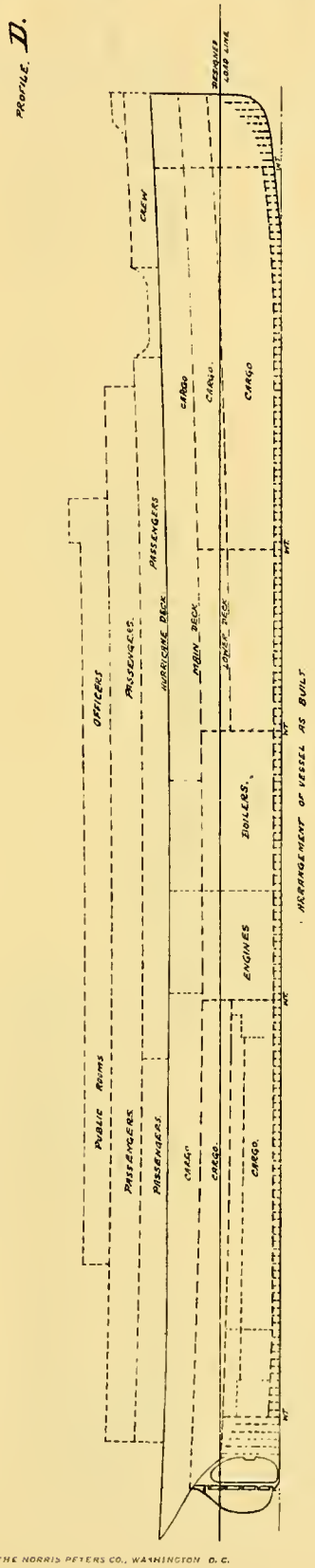

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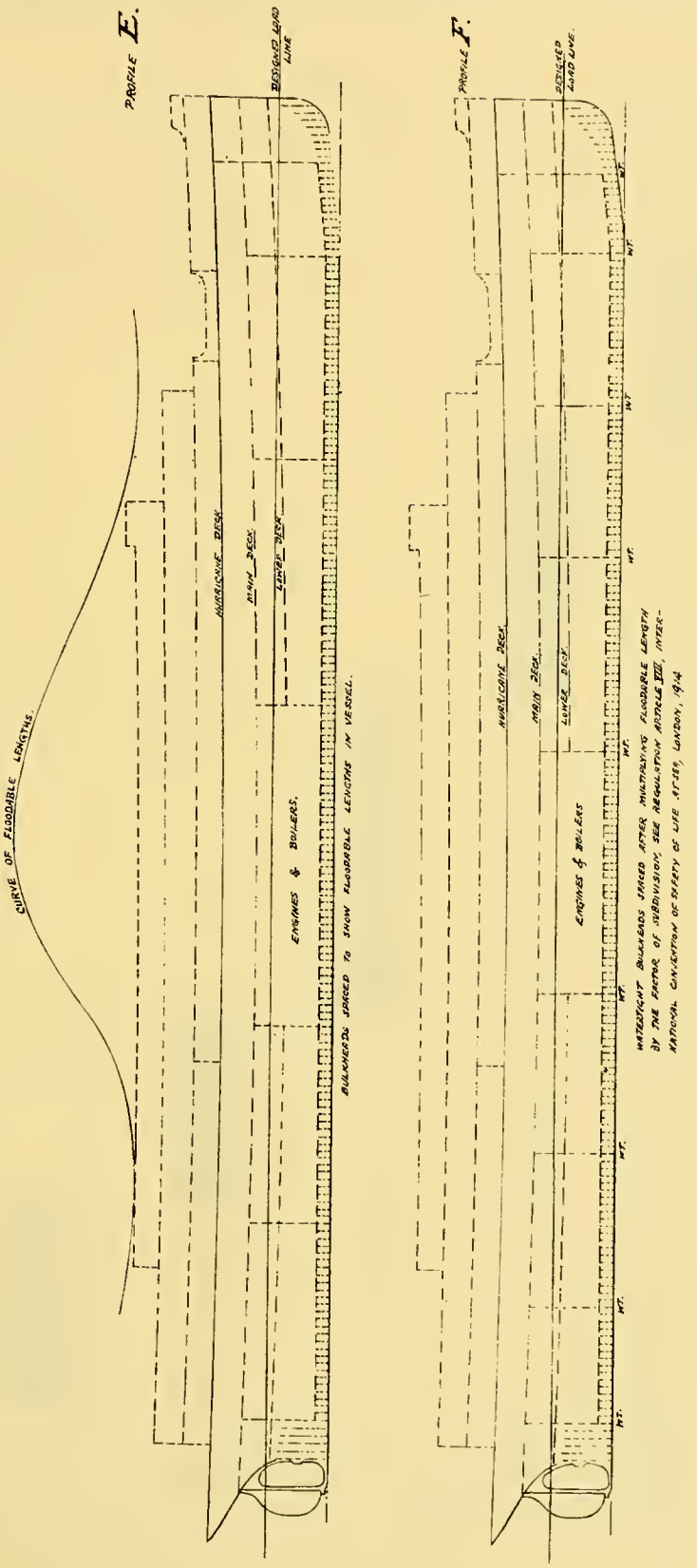

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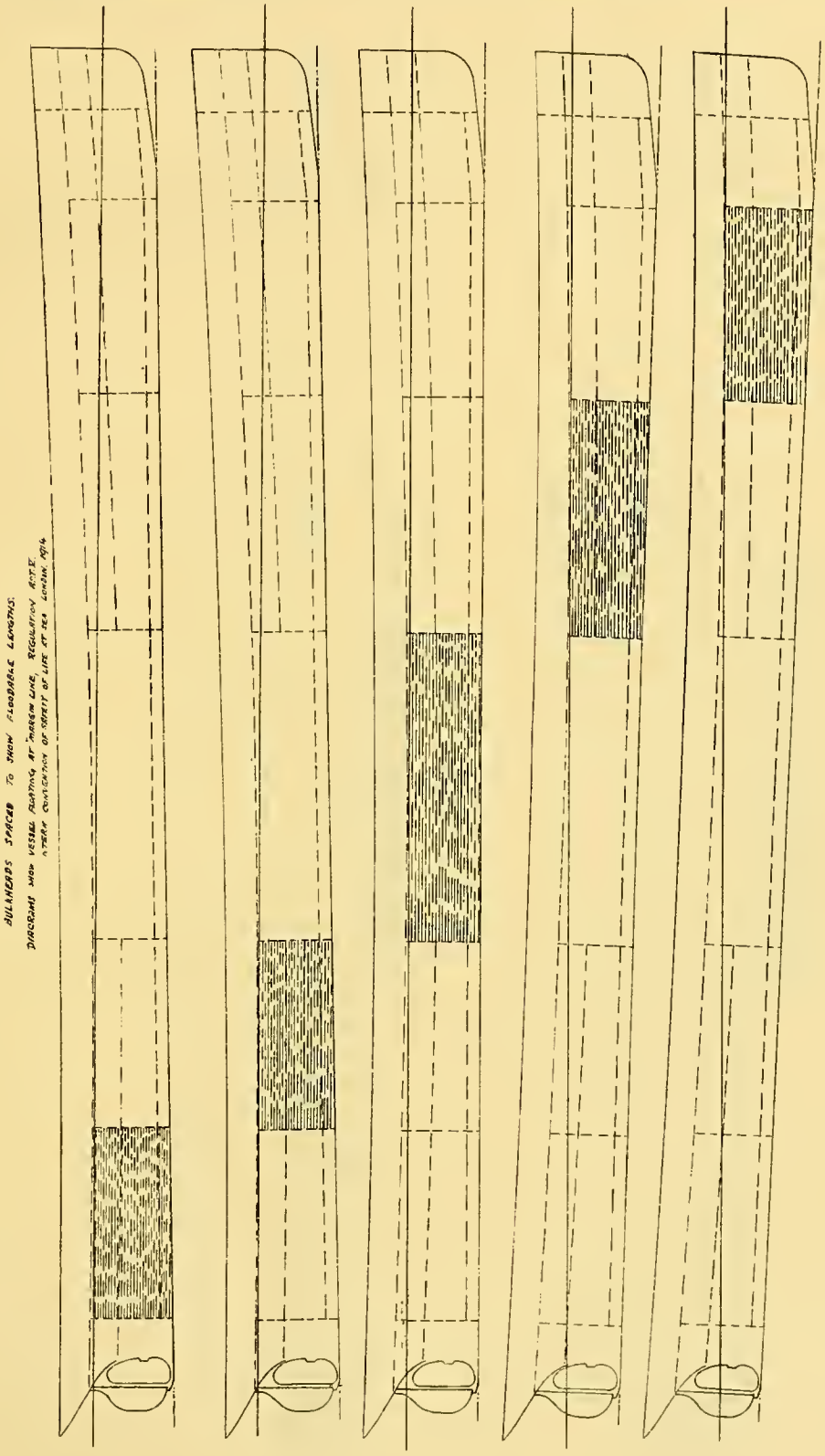

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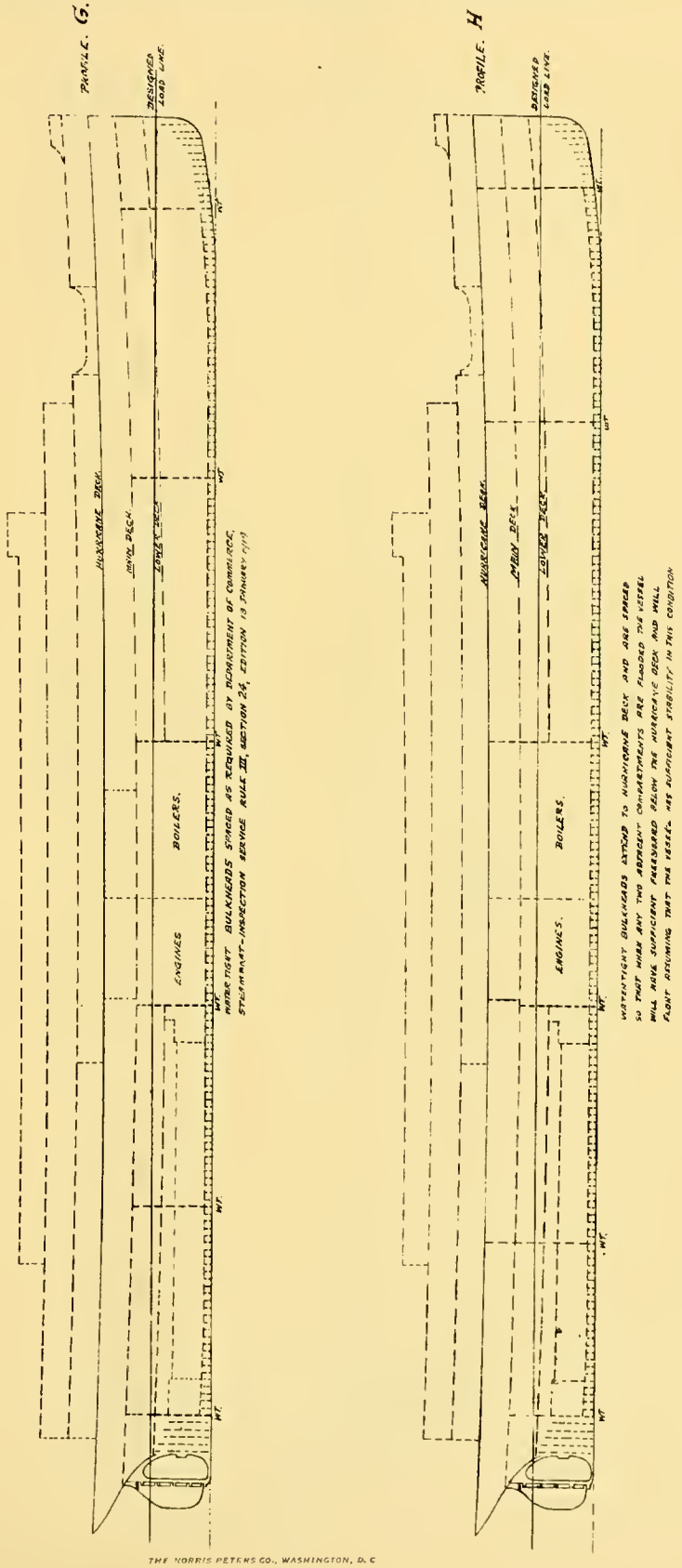

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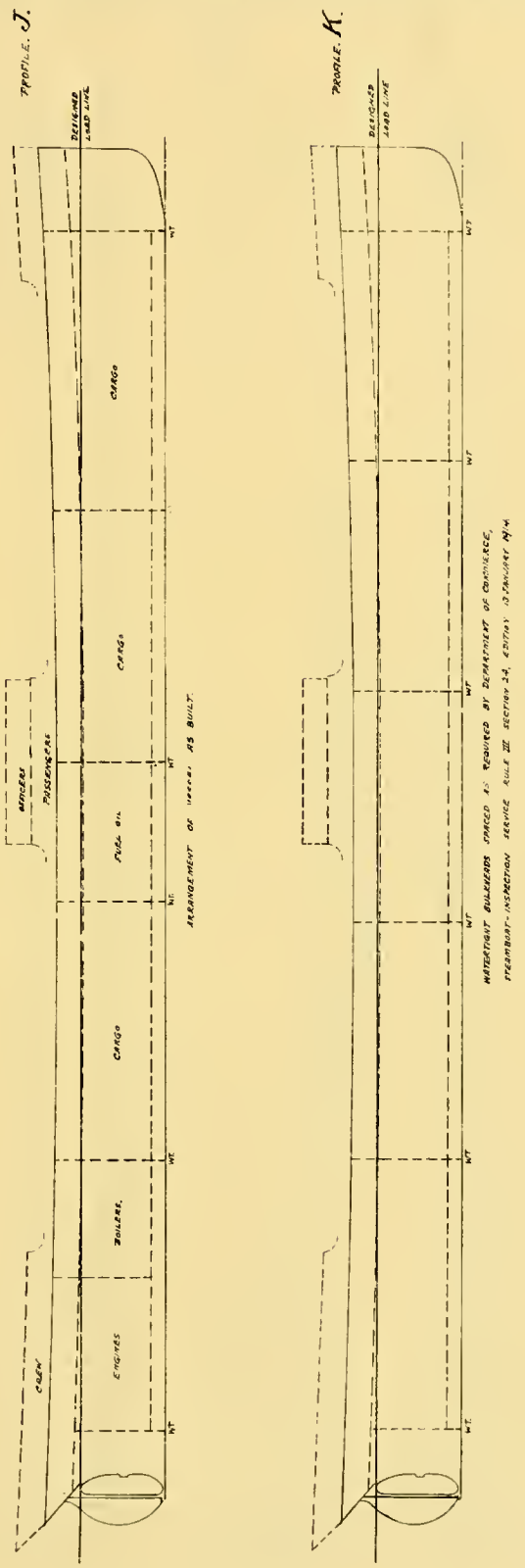

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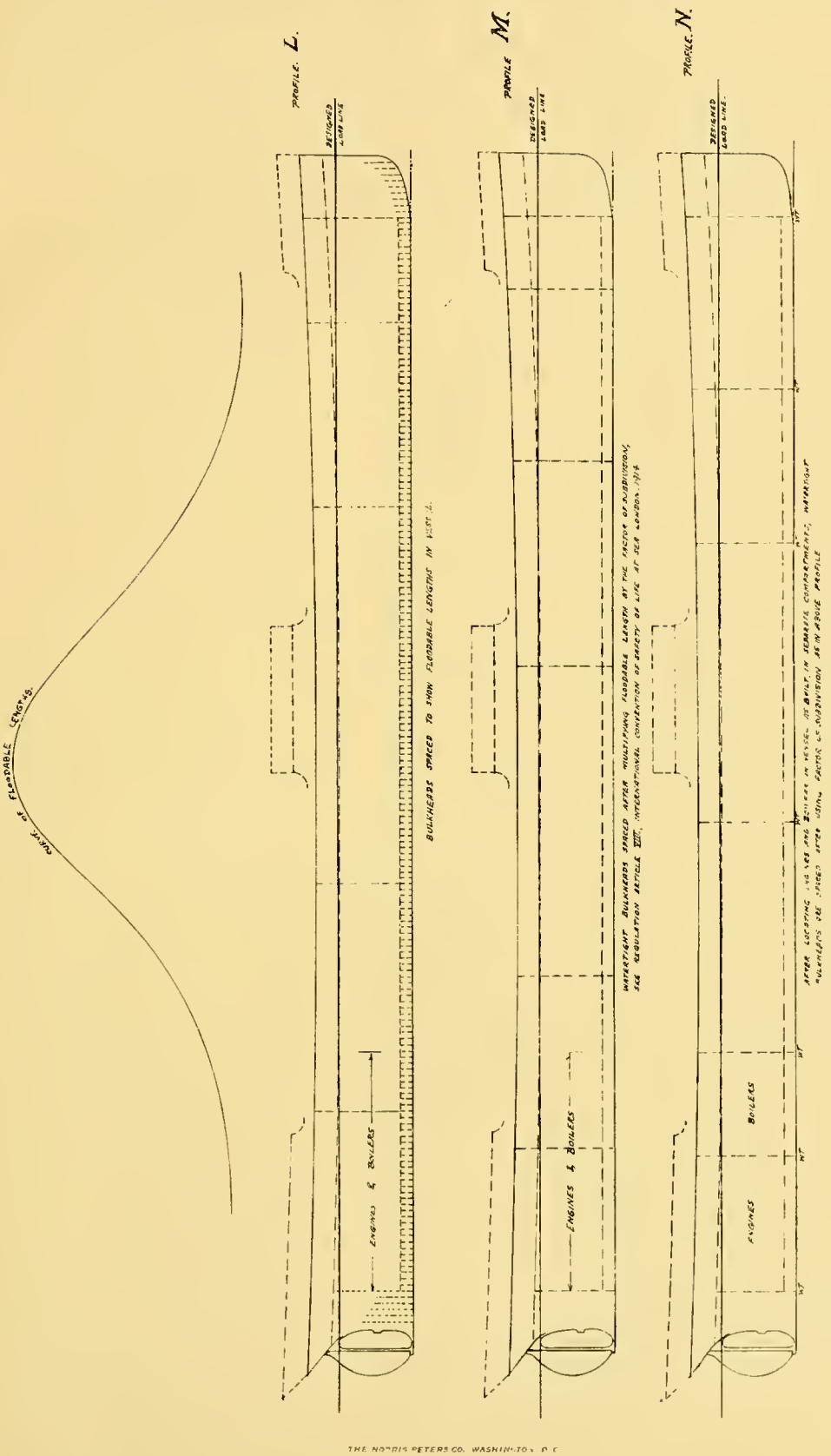

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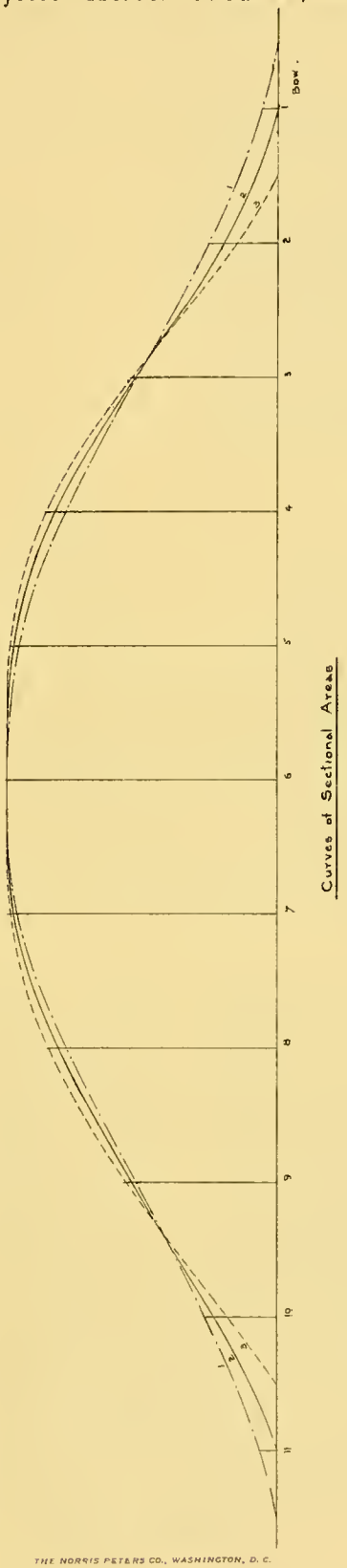
To illustrate paper on "The Expansion or Contraction of Dimensions and the Effect upon Resistance," by Professor Herbert C. Sadler, Member of Council.



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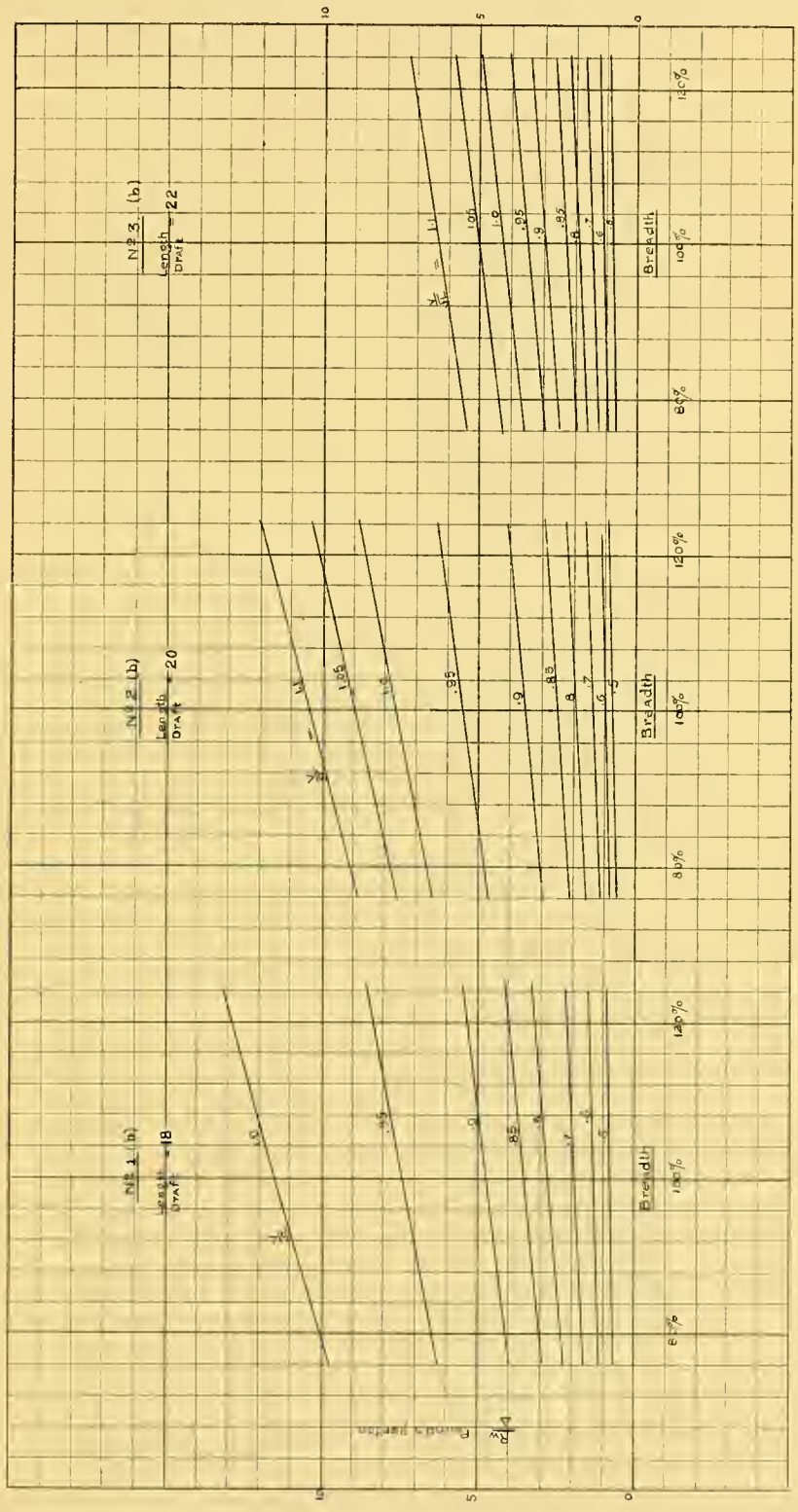

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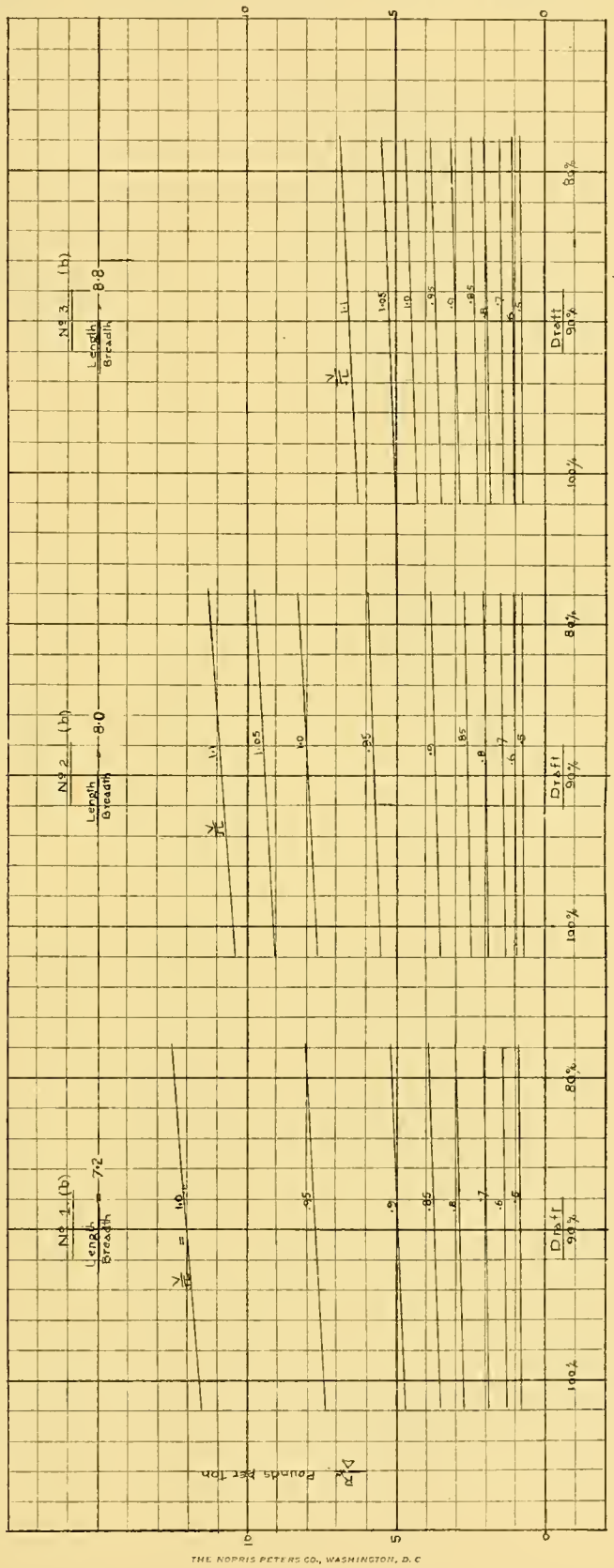

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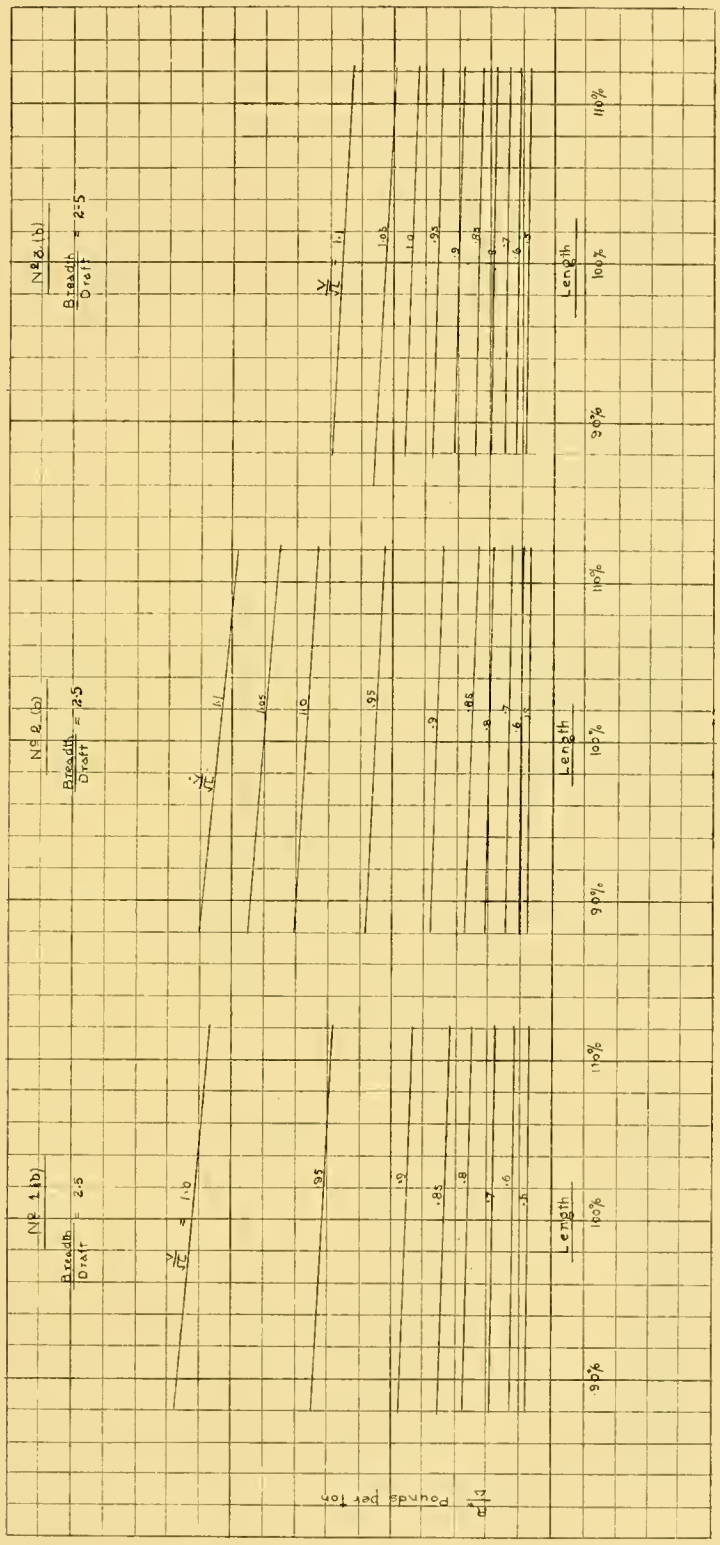

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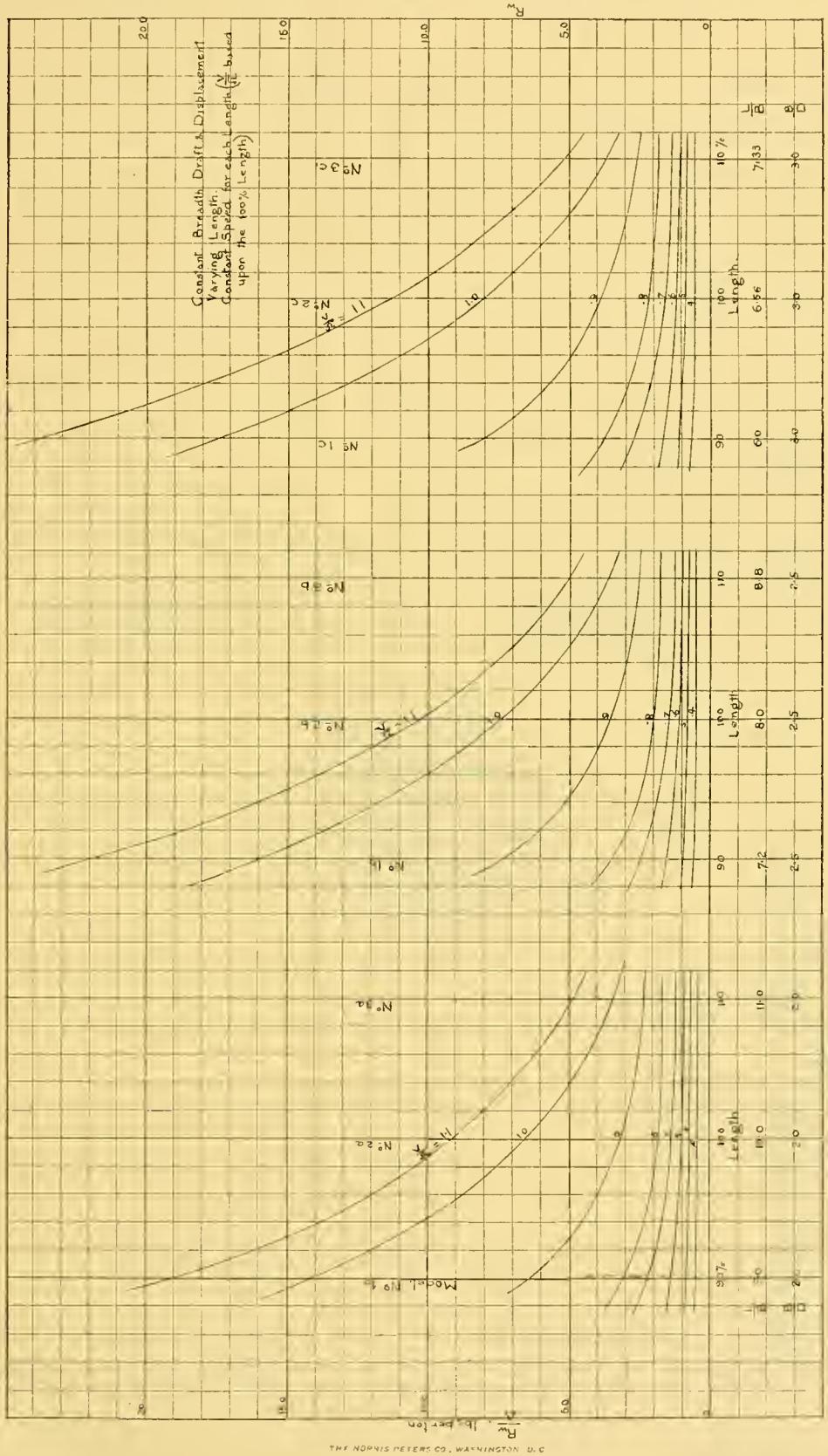
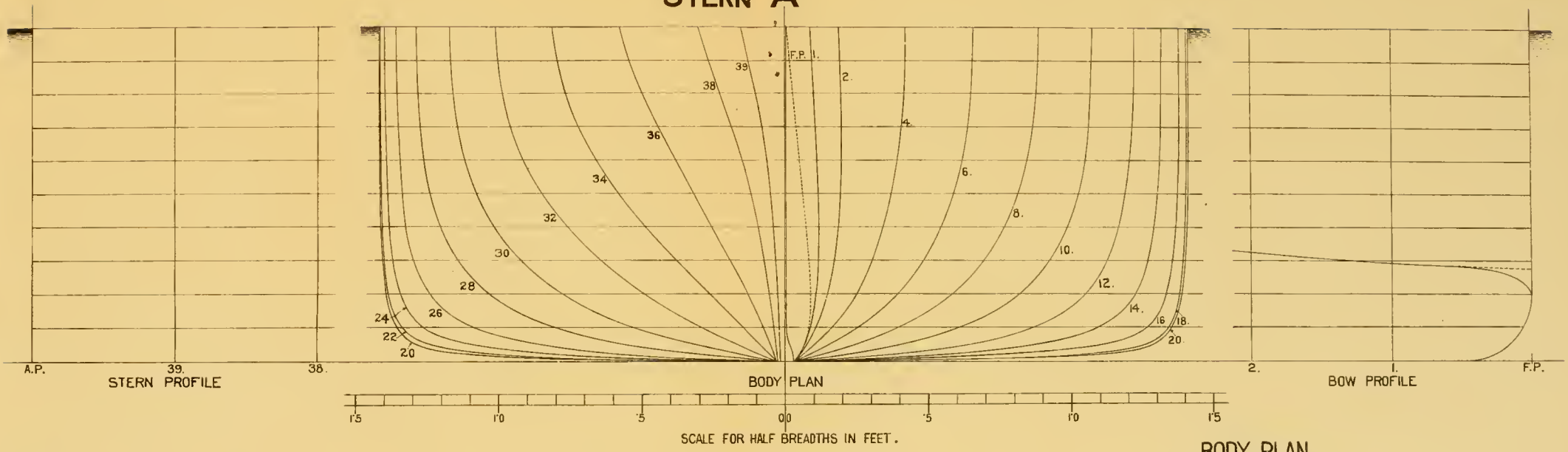


To illustrate paper on "Some Experiments with Models having Radical Variations of After Sections," by Naval Constructor D. W. Taylar, U. S. N., Vice-President.

STERN A



BODY PLAN,
BOW AND STERN PROFILE
SHOWING STERN A
AND BOW FOR ALL STERNS;
AND
CURVE OF SECTIONAL AREAS
FOR THE SAME

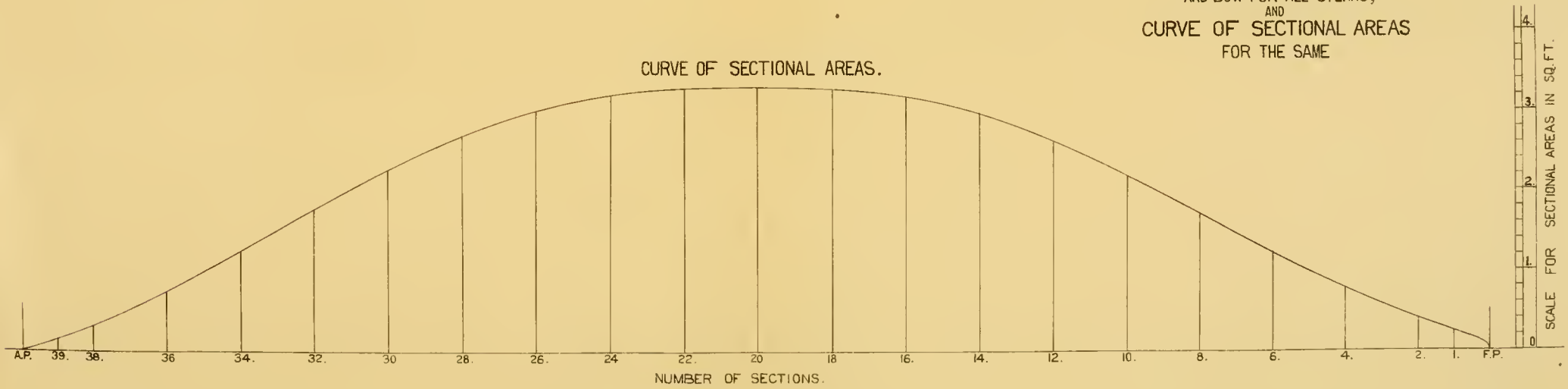


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Fig. 1.

To illustrate paper on "Some Experiments with Models having Radical Variations of After Sections," by Naval Constructor D. W. Taylor, U. S. N., Vice-President.

STERN B.

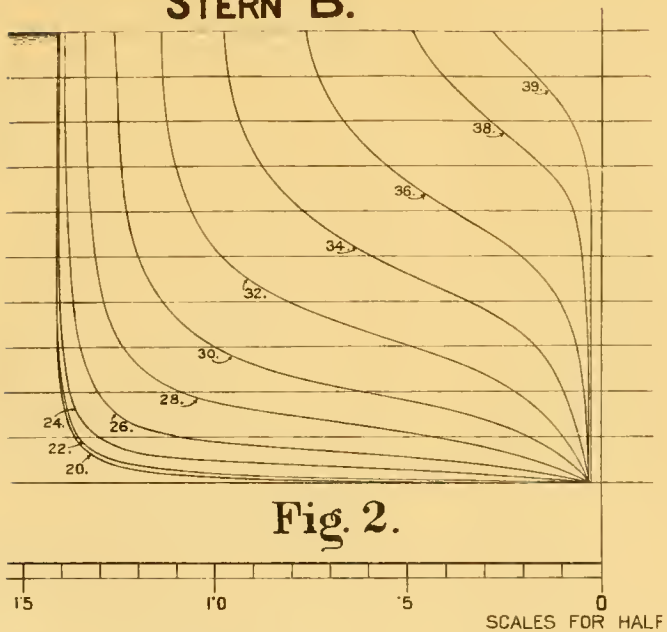

Fig. 2.

STERN C.

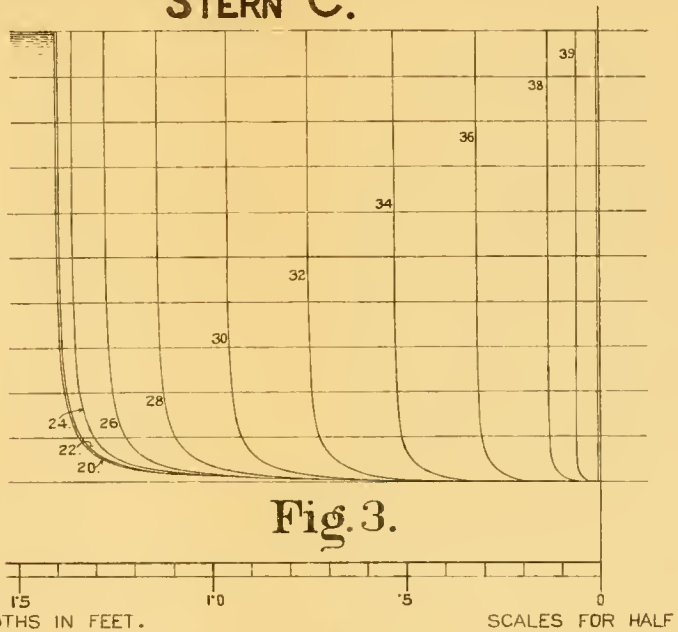

Fig. 3.

STERN D.

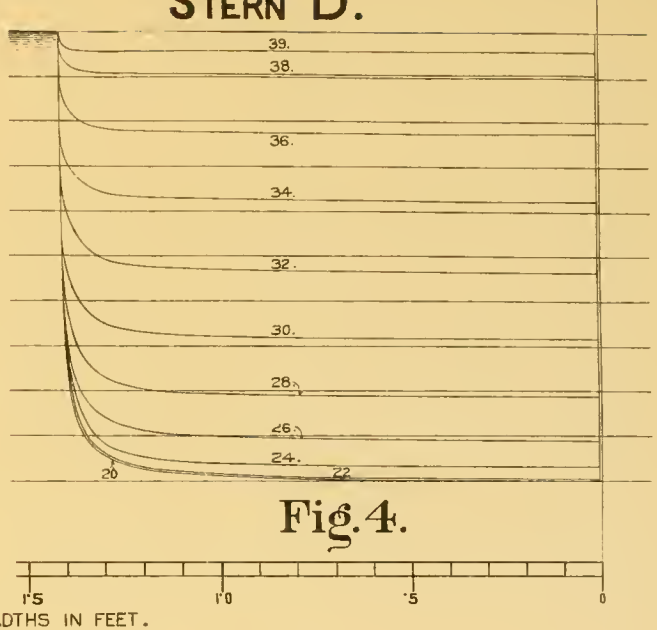

Fig. 4.

SCALES FOR HALF BREADTHS IN FEET.

SCALES FOR HALF BREADTHS IN FEET.

STERN E.

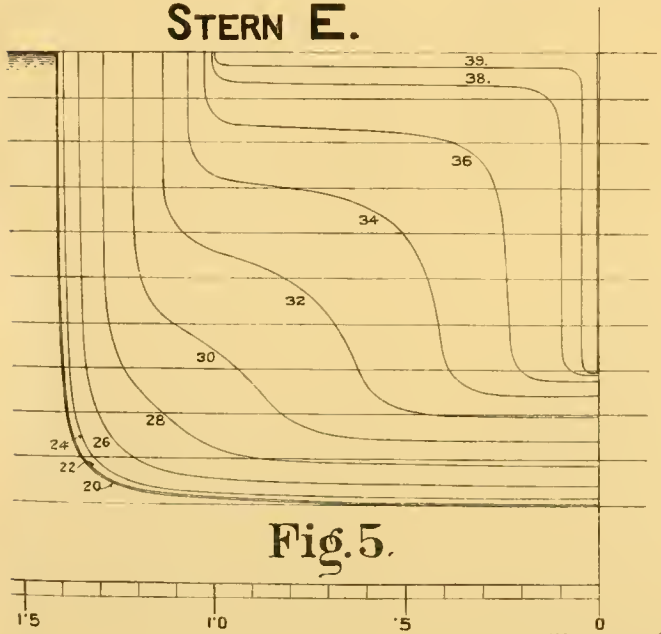

Fig. 5.

STERN F.

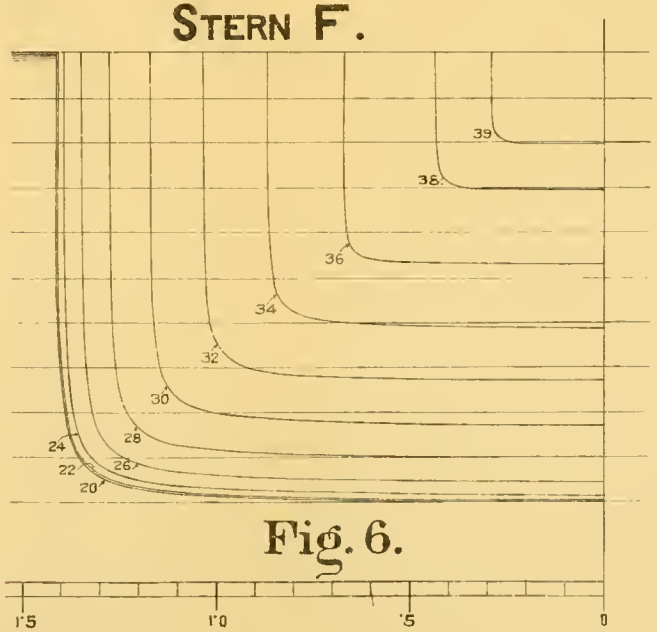

Fig. 6.

SCALES FOR HALF BREADTHS IN FEET.

HALF BODY PLANS
OF
FIVE STERNS
B, C, D, E, F.

To illustrate paper on "Some Experiments with Models having Radical Variations of After Sections," by Naval Constructor D. W. Taylor, U. S. N., Vice-President.

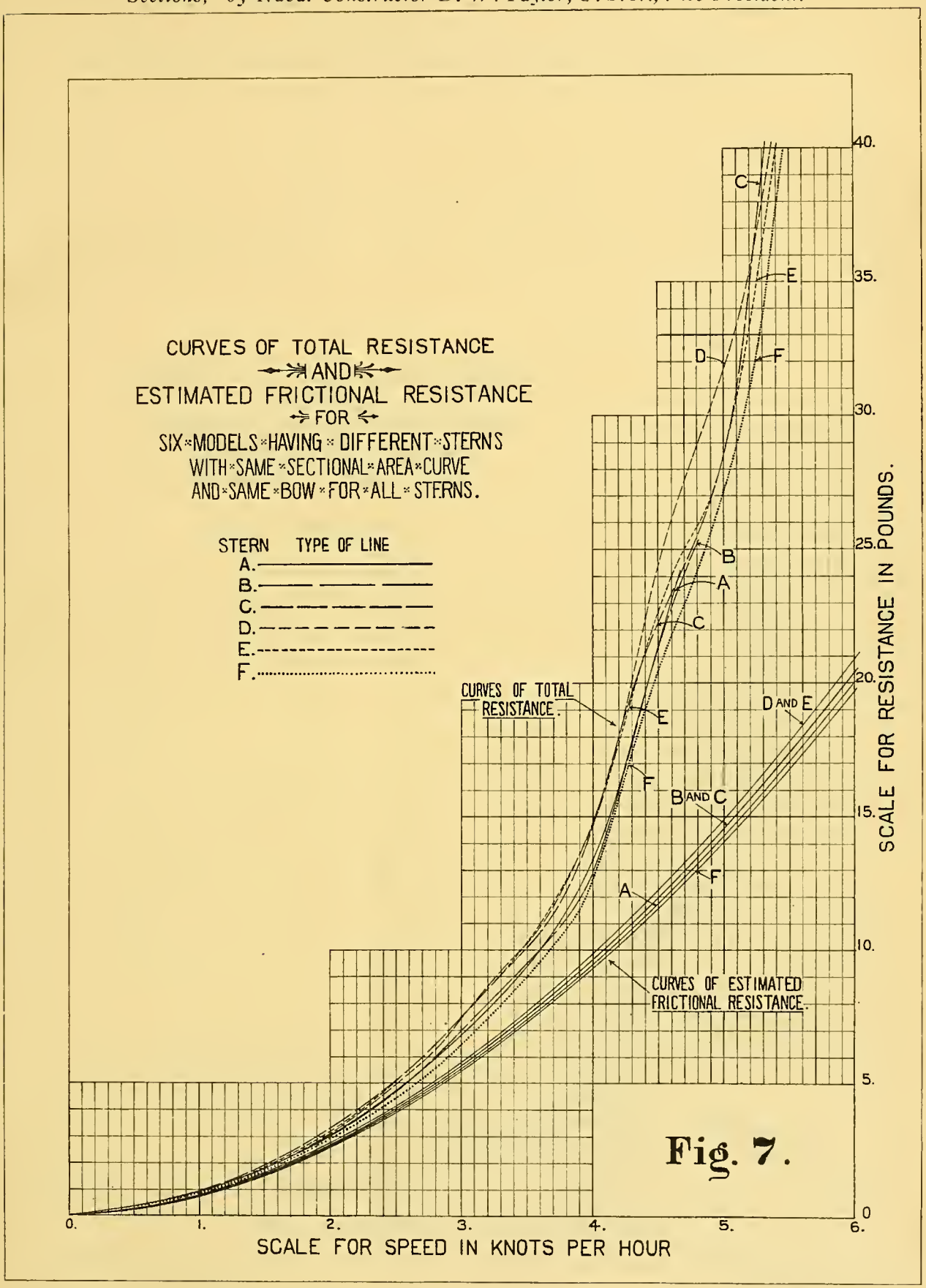

Fig. 7.

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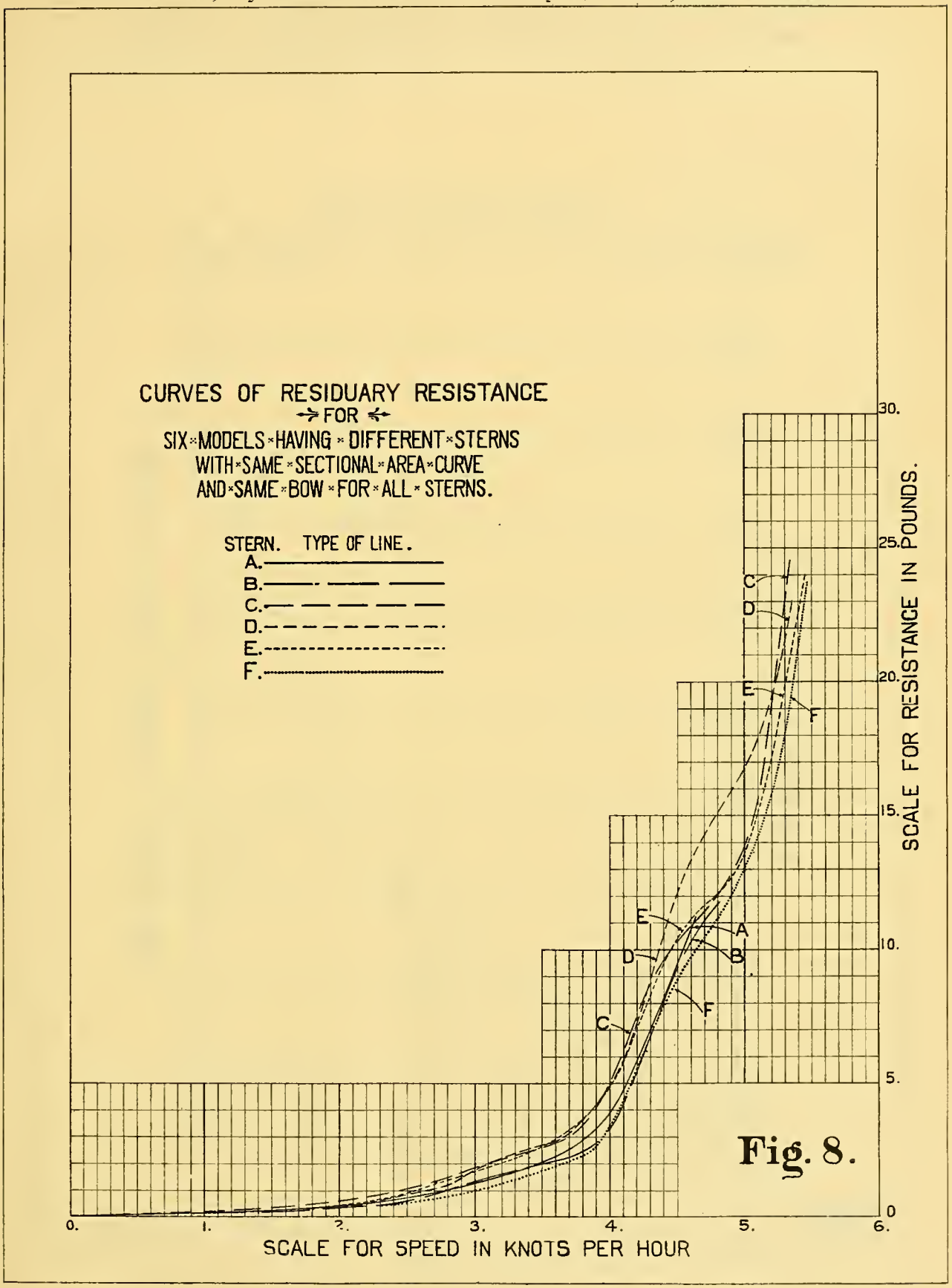

Fig. 8.

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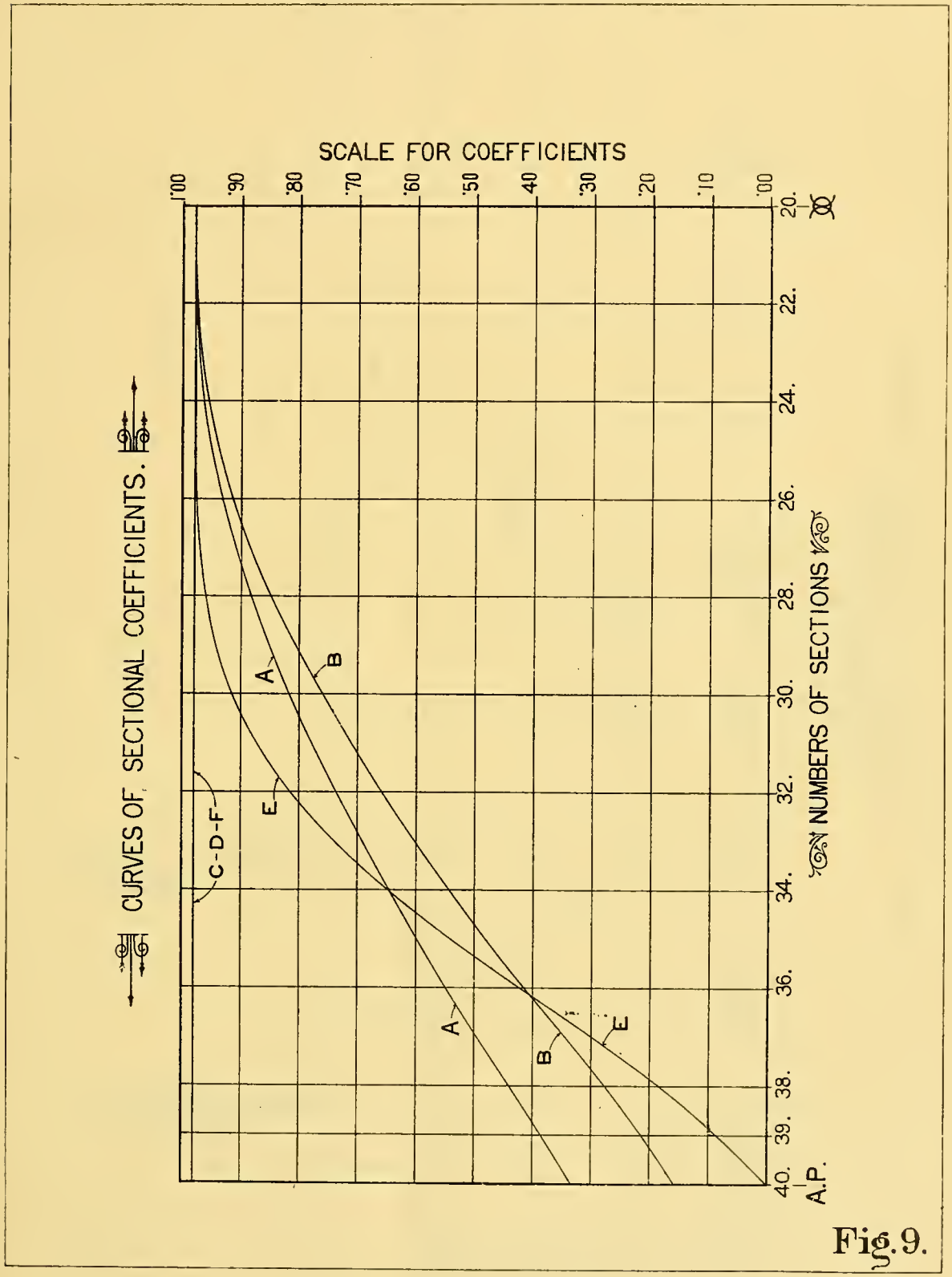

Fig. 9.

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To illustrate paper on "Stability of Vessels as Affected by Damage due to Collision," by William Gatewood, Esq., Member.

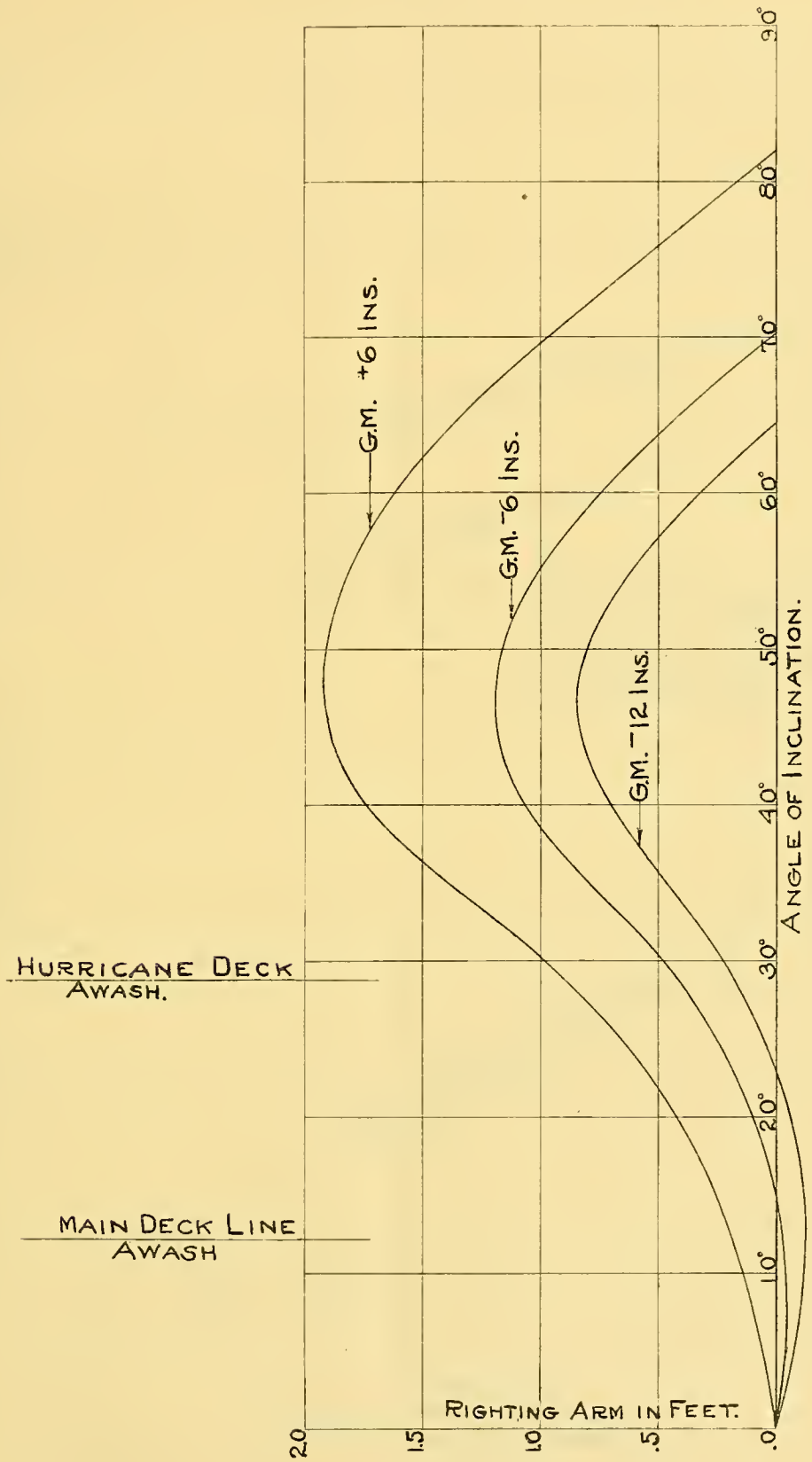

FIGURE 1.
STABILITY CURVE
370 FT. STEAMSHIP—INTACT—21.7 FT. DRAFT.

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To illustrate paper on "Stability of Vessels as Affected by Damage due to Collision," by William Gatewood, Esq., Member.

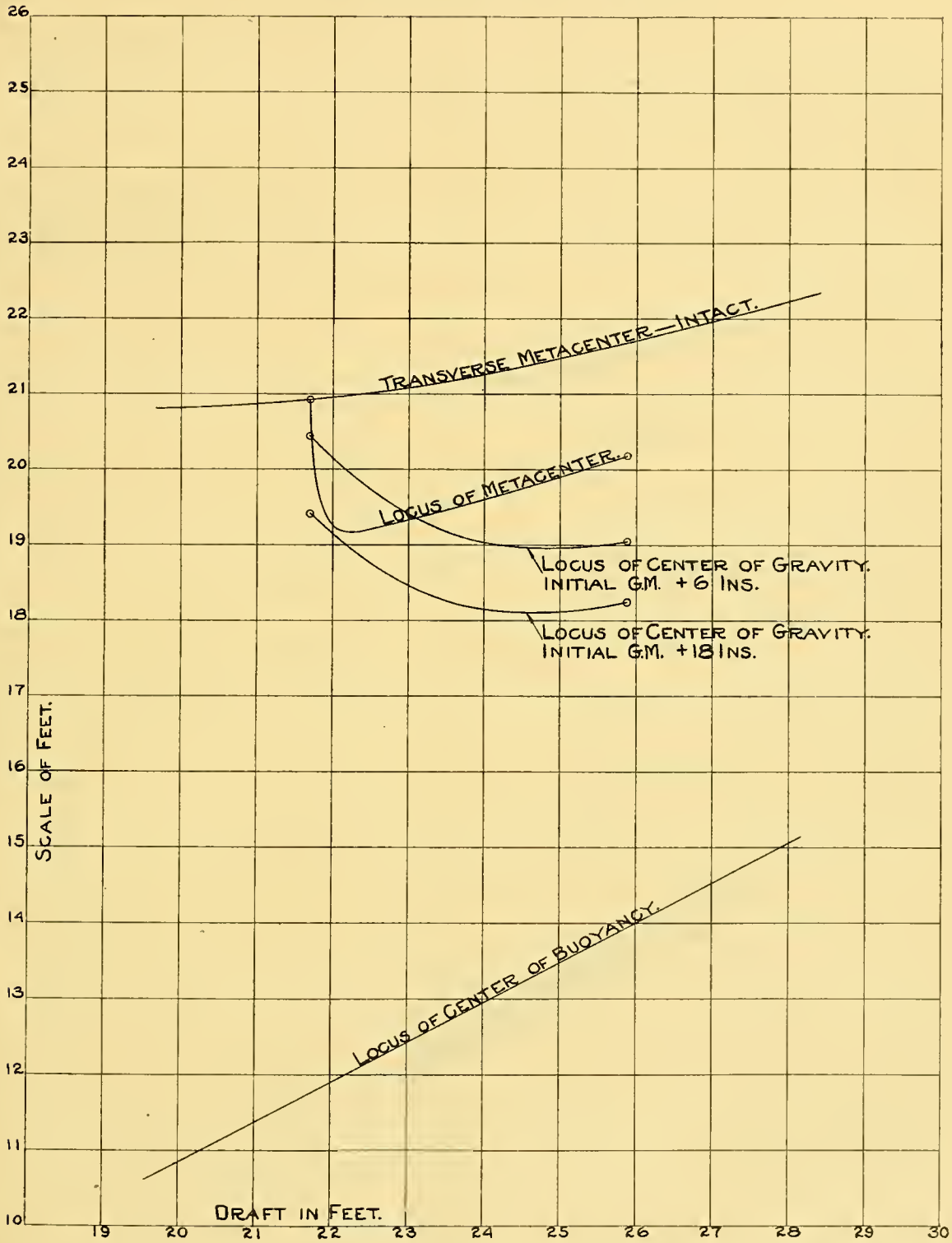


FIGURE 2.
VARIATION OF INITIAL STABILITY
IN FLOODING MACHINERY COMPARTMENT.

THE NORRIS PETERS CO., WASHINGTON, D.

To illustrate paper on "Stability of Vessels as Affected by Damage due to Collision." by William Gatewood, Esq., Member.

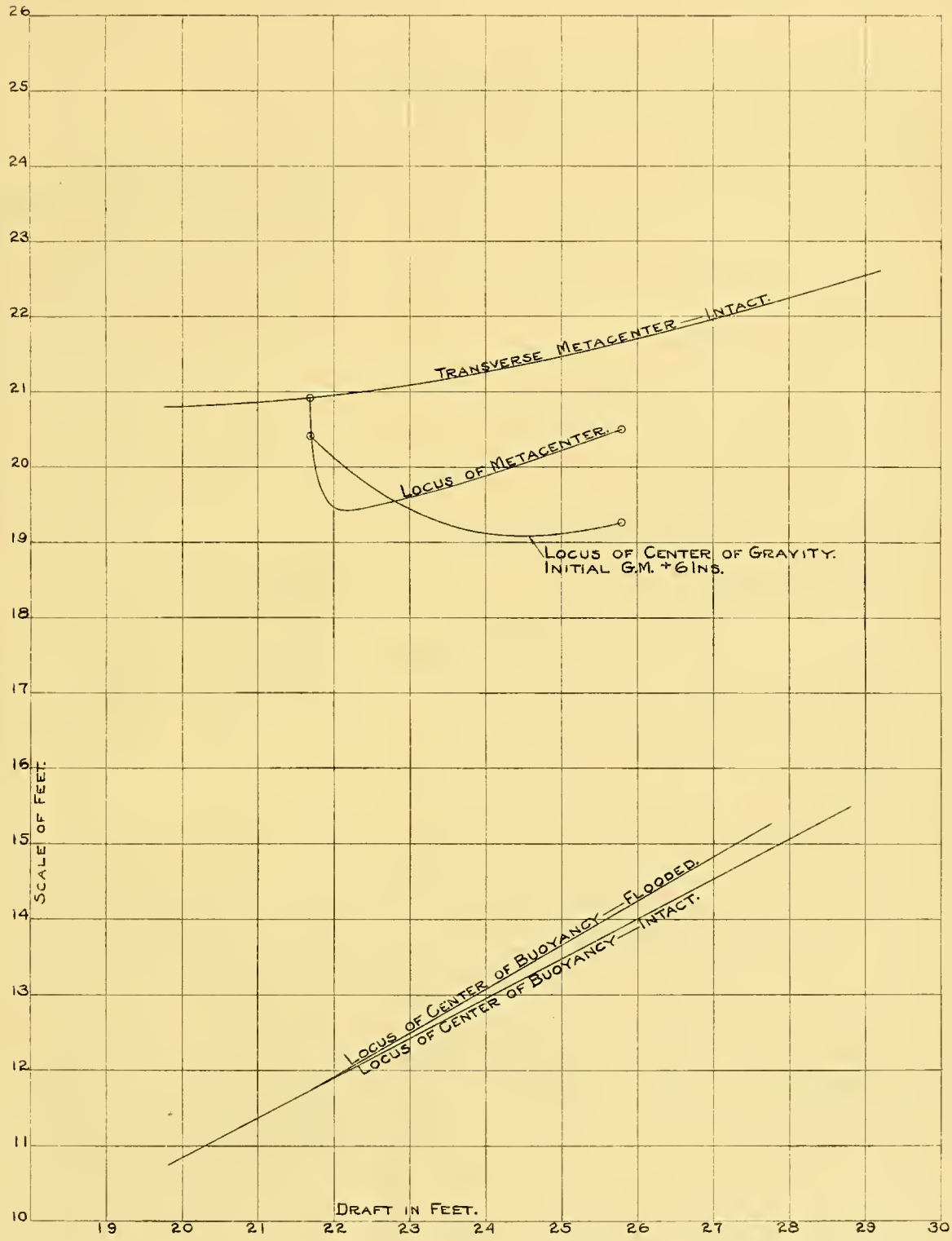


FIGURE 3.

VARIATION OF INITIAL STABILITY IN FLOODING #2 HOLD.

THE HORRIS PETERS CO., WASHINGTON, D. C

To illustrate paper on "The Thermodynamics of the Marine Oil Engine," by John F. Wentworth, Esq., Visitor.

THE INTERNAL COMBUSTION ENGINE AS A RECORDING THERMOMETER

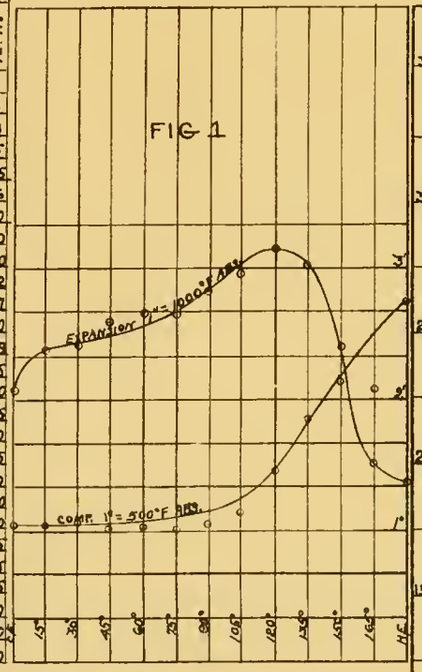
TABLE 1

NO.	CRANK ANGLE	PISTON TRAVEL	VOL. %	SPECIFIC VOL.	PRESS. SCALED.	TEMP. BY CALCUL.	TEMP. BY CURV.	PRESS. FROM TEMP.	GLASS TEMP.
1	C.E. 0	1.00	1000	13.09	14.7	520	524	14.7	60
2	15	.985	987	12.92	15.5	524	524	15.	64
3	30	.945	950	12.42	15.5	532	528	15.4	68
4	45	.895	904	11.83	16.	542	535	16.7	75
5	60	.795	810	10.60	18	516	545	19	85
6	75	.690	712	9.30	20	504	566	22.5	106
7	90	.560	592	7.74	25	524	600	28.7	140
8	105	.425	465	6.08	35	576	670	41.4	210
9	120	.295	345	4.52	60	733	750	61.4	290
10	135	.170	228	2.92	115	928	912	113.	452
11	150	.075	140	1.83	215	1064	1087	218.	627
12	165	.021	089	1.16	330	1035	1250	398	790
13	H.E. 180	Beg. comp.	075	.99	515	1378	1378	515	918
14	15	.021	089	1.16	485	1525			1065
15	30	.075	140	1.83	373	2400			1940
16	45	.170	228	2.92	257	3015			2555
17	60	.295	345	4.52	180	3140			2680
18	75	.425	465	6.08	135	2965			2505
19	90	.560	592	7.74	105	2830			2370
20	105	.690	712	9.30	93	2650			2190
21	120	.795	810	10.60	83	2660			2200
22	135	.895	904	13.70	70	2595			2195
23	150	.945	950	16.20	55	2415			1955
24	165	.985	987	18.75	45	2385			1925
25	C.E. 0	1.000	1000	24.85	30	2020			1560
26	15	.985	987	33.35	20	1800			1340
27	30	.945	950	40.65	14.7	1620			1160

NO APPRECIABLE CHANGE FROM CALCULATED TEMPERATURES

NO APPRECIABLE CHANGE FROM SCALED PRESSURES

FIG 1



NOTE:

GOOD RESULTS CAN BE OBTAINED FROM AN ACTUAL CARD BY ENLARGING THE CARD AS SHOWN BY FIG. 2. OR BY SCALING PRESSURE, CALCULATING THE TEMPERATURE, PLOTTING THE RESULTING FIGURES AND DRAWING A SMOOTH CURVE THROUGH THESE POINTS. BY MEANS OF THE NEW TEMPERATURE POINTS PRESSURES CAN BE DETERMINED BEYOND THE ACCURACY OF THE INDICATOR.

FORMULA $PV = RT$

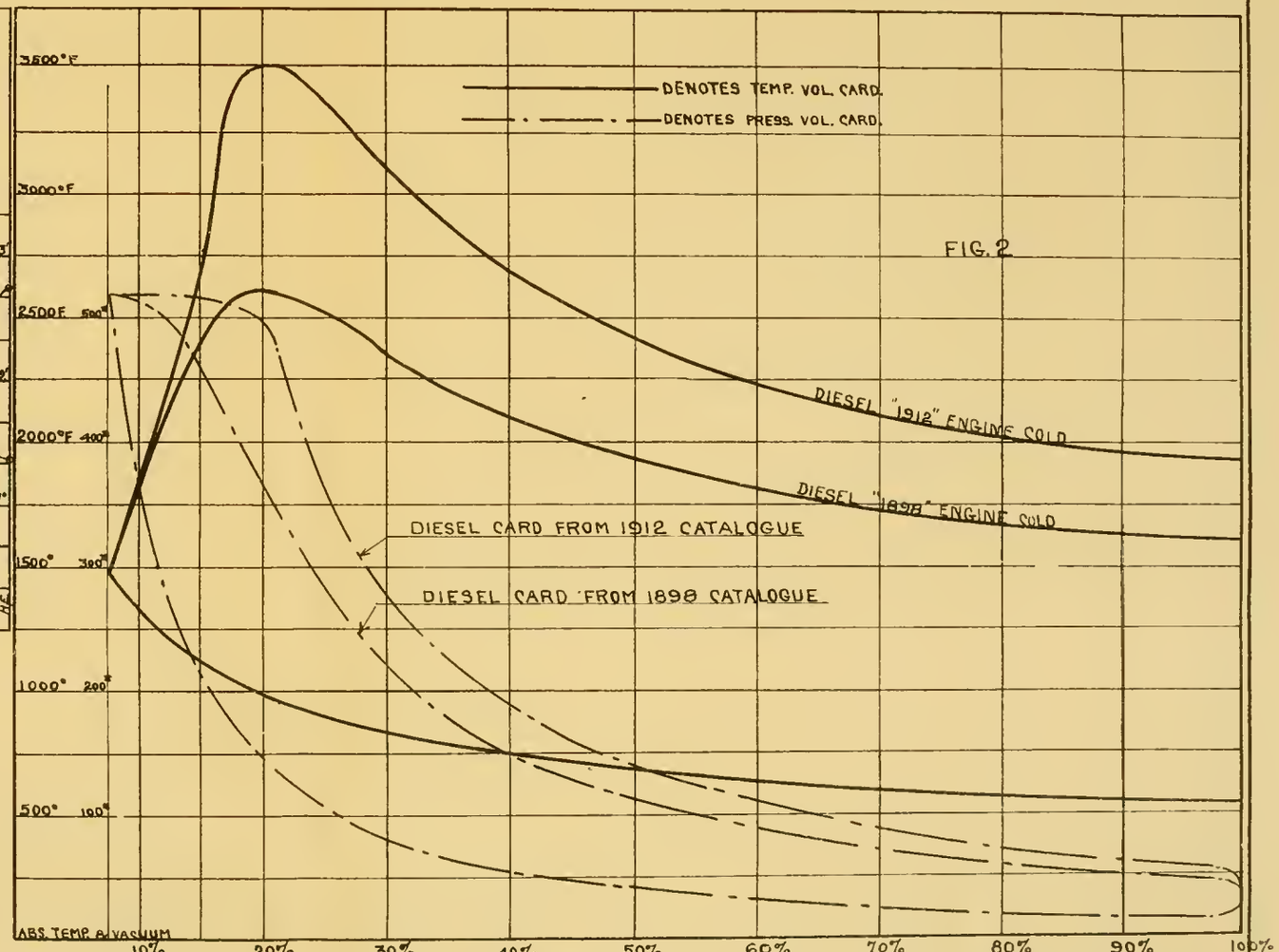
P = ABS. PRESS. PER □" R = CONSTANT, 53.22 FOR AIR.

V = CU. FT TO 1 LB. OF AIR T = ABS. TEMP = GLASS READ. + 460.7°F

IN THIS WORK THE TEMP. AT BEGINNING OF COMPRESSION HAS BEEN ASSUMED. THIS FIGURE IS VERY UNCERTAIN. FOR EXACT EXPERIMENTS IT IS SUGGESTED THAT THE TEMPERATURE OF THE EXHAUST BE DETERMINED BY PYROMETER AND RESULTS FIGURED BACKWARD FROM THE EXHAUST.

THE ERROR IN THIS WILL NOT CHANGE THE SHAPE OF THE TEMPERATURE CURVES GIVEN.

FIG. 2

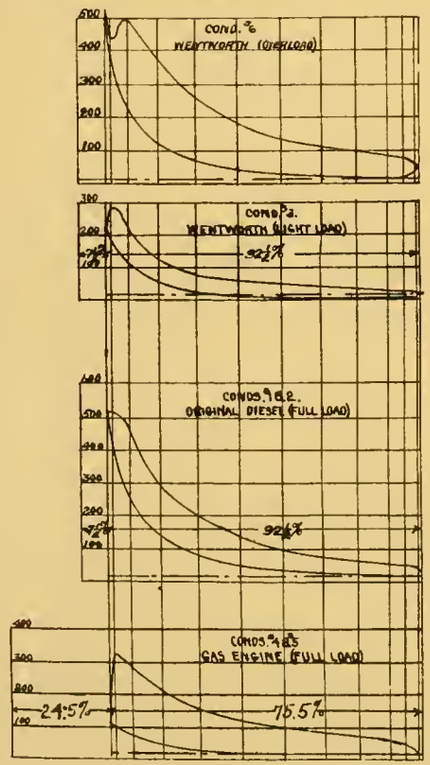


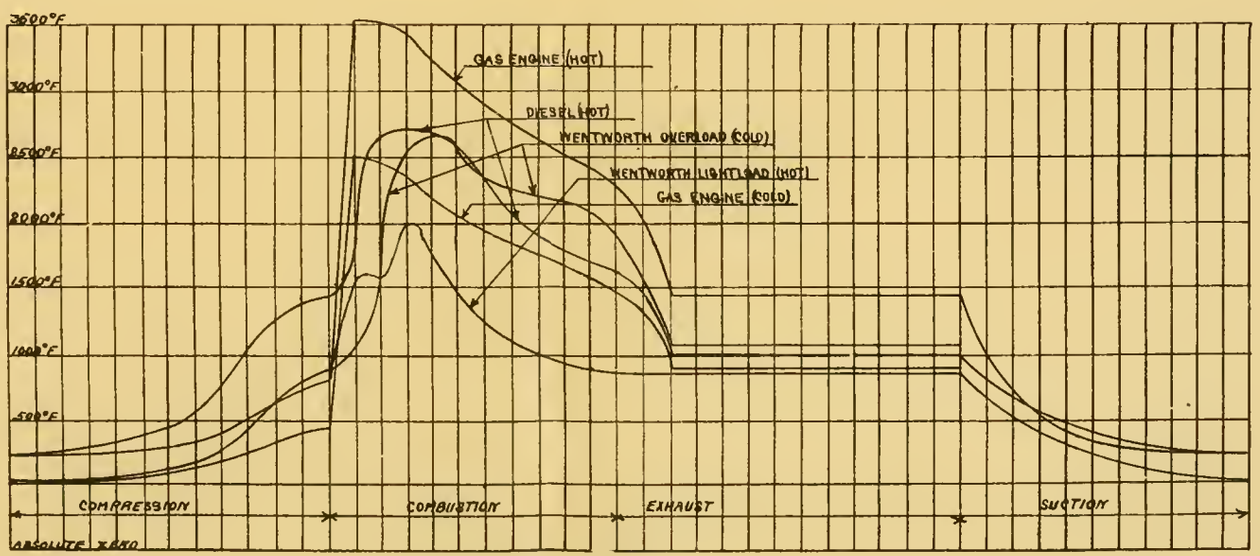
John F. Wentworth
June 13 1914

THE MORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Thermodynamics of the Marine Oil Engine," by John F. Wentworth, Esq., Visitor.

		COMPRESSION													COMBUSTION												EXHAUST												SUCTION											
DEGREES OF CRANK ANGLE		180	195	210	225	240	255	270	285	300	315	330	345	360	375	390	405	420	435	450	465	480	495	510	525	540	555	570	585	600	615	630	645	660	675	690	705	720	15	30	45	60	75	90	105	120	135	150	165
DIESEL ENGINE ENGINE COLD	TEMP.	60	65	67	84	113	145	212	265	420	635	715	872	920	1170	1790	1840	2040	1740	1530	1325	1230	1170	1105	1090	600	450	450	450	450	450	450	450	450	450	450	450	60	60	60	60	60	60	60	60	60	60	60
	PRES.	0	3	11	23	53	9	17	30	57	121	222	410	505	501	438	270	190	122	80	56	44	36	32	30	15	5	5	5	5	5	5	5	5	5	5	5	5	0	-5	-5	-5	-5	-5	-5	-5	-5	-5	0
DIESEL ENGINE ENGINE HOT	TEMP.	260	266	270	293	333	377	468	543	758	1055	1165	1381	1450	1790	2660	2720	2660	2580	2300	2010	1880	1800	1710	1690	1465	988	988	988	988	988	988	988	988	988	988	988	600	550	400	300	290	280	270	260	260	260	260
	PRES.	0	3	11	23	53	9	17	30	57	121	222	410	505	501	438	270	190	122	80	56	44	36	32	30	15	5	5	5	5	5	5	5	5	5	5	5	5	0	-5	-5	-5	-5	-5	-5	-5	-5	-5	0
WENTWORTH ENGINE ENGINE HOT	TEMP.	60	65	67	85	113	145	212	265	420	635	715	872	920	1570	1985	2000	1750	1440	1240	1140	990	940	915	900	890	890	890	890	890	890	890	890	890	890	890	890	890	700	600	400	300	212	145	135	84	67	65	60
	PRES.	-8.2	8.1	7.1	-7.2	-5.8	-4.1	-.5	5.2	17.2	45	90	172	215	270	200	120	65	41	32	22	14	10	8	7	0	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.0	-.5	-.5	-.5	-.5	-.4	-.58	-7.2	-7.7	-8.1	-8.2
GAS ENGINE ENGINE COLD	TEMP.	60	60	62	65	72	85	127	155	200	255	340	415	452	2500	2480	2380	2160	2050	2010	1850	1780	1660	1610	1501	1312	919	919	919	919	919	919	919	919	919	919	919	60	60	60	60	60	60	60	60	60	60	60
	PRES.	0	0	0	1.	1.4	3.1	5.	10	13	24	39	80	90	305	260	190	143	111	81	70	60	45	35	20	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	0	-.5	-.5	-.5	-.5	-.5	-.5	-.5	-.5	-.5	-.8
GAS ENGINE ENGINE HOT	TEMP.	260	260	265	268	277	295	325	364	426	531	647	752	802	3640	3520	3475	3200	3030	2960	2760	2640	2490	2410	2320	1990	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1000	760	500	400	360	300	290	280	270	260	260
	PRES.	0	0	0	1	1.4	3.1	5.	10	13	24	39	80	90	305	260	190	143	111	81	70	60	45	35	20	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	0	-.5	-.5	-.5	-.5	-.5	-.5	-.5	-.5	-.5	.0
WENTWORTH ENGINE OVERLOAD, ENGINE COLD	TEMP.	60	64	68	75	85	106	140	210	290	452	627	790	918	1065	1940	2555	2680	2505	2310	2190	2200	2195	1955	1925	1560	1340	1160	1160	1160	1160	1160	1160	1160	1160	1160	1160	60	60	60	60	60	60	60	60	60	60	60
	PRES.	0	.3	.7	1.	2.3	7.8	14.	32.	46	98	203	383	500	470	358	242	165	120	90	78	68	55	40	30	15	5	0	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	0	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3





TEMPERATURE CURVES

John F. Wentworth
May 27 1914

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Thermodynamics of the Marine Oil Engine," by John F. Wentworth, Esq., Visitor.

DATA CONCERNING INJECTION AIR.

HORSE-POWER DEVELOPED TO COMPRESS 100 CU. FT FREE AIR FROM ATMOSPHERE TO VARIOUS PRESSURES

GAUGE PRESSURE POUNDS	ONE-STAGE COMPRESSION D.H.P.	TWO-STAGE COMPRESSION D.H.P.	FOUR-STAGE COMPRESSION D.H.P.	TEMPERATURE FOR ADIABAT	TEMPERATURE FOR ISOTH.	VOLUME CU.FT. FOR AD. COMP.	VOLUME CU.FT. FOR ISOT. COMP.
60	13.41	11.70	10.80	372°F	59°F	31.35	19.60
80	15.94	13.70	12.50	431°F	" "	26.50	15.49
100	18.15	15.40	14.20	489°F	" "	23.22	12.83
200	× 27.50	21.20	18.75	704°F	" "	14.88	7.20
300	× 32.10	24.50	21.80	810°F	" "	11.40	4.67
400	× 36.40	27.70	24.00	912°F	" "	9.32	3.50
500	× 40.30	29.75	25.90	1004°F	" "	7.97	2.83
600	× 43.30	31.70	27.50	1075°F	" "	7.00	2.38
700	× 46.00	33.50	28.90	1130°F	" "	6.27	2.05
800	× 48.70	34.90	30.00	1201°F	" "	5.75	1.80
900	× 51.20	36.30	31.00	1258°F	" "	5.28	1.60
1000	× 53.30	37.80	31.80	1308°F	" "	4.90	1.45

× CALCULATED ON BASIS OF 72% EFF.

HORSE POWER INDICATED BY EXPANDING BETWEEN PRESSURES GIVEN INITIAL TEMP. 60° F.

FORMULA $W = \frac{PV}{K-1}\left(1-\left(\frac{V}{V_1}\right)^{K-1}\right)$ V = ORIG. VOL. V_1 = FINAL "

1000 TO 30	9.47
900 " 30	9.23
800 " 30	8.98
700 " 30	8.73
600 " 30	8.38
500 " 30	7.93
400 " 30	7.36
300 " 30	6.64
200 " 30	5.93

EFFECT ON EFFICIENCY BY VARYING CONDITION OF INJ. AIR.

B.H.P. OF ENGINE	COMP. PRESS IN ENG.	B.H.P. OF AIR COMP.	PRESS. OF INJ. AIR	TEMP. OF INJ. AIR	LOSS IN INJ. AIR	% SAVING IN AIR POWER	EFF. BASED ON B.H.P.
2000	500 LBS.	800	1000 LBS	60°F	141 H.P.	—	25%
2000	500 "	100	1000 "	580°F	41 "	50%	26.3%
2000	250 "	100	500 "	60°F	70 "	50%	26.3%
2000	250 "	50	500 "	580°F	19 "	75%	27.1%

NOTE: IT IS VERY INTERESTING TO NOTE THAT THE TOTAL ENERGY IN COMPRESSED AIR DEPENDS UPON ITS WEIGHT AND TEMPERATURE. THE PRESSURE HAS NO EFFECT.

ASSUME 1 LB. OF AIR AT 1000 LBS. PRESSURE AND 520°F AND ONE LB. AT 100 LBS. PRESS. 16 H.P. COULD BE DEVELOPED IN EACH CASE IF THE AIR COULD BE EXPANDED TO ABS. VACUUM.

FORMULA IS $W = PXV \div (K-1)$. AT ALL TEMPERATURES, PXV IS A CONSTANT FOR EACH TEMPERATE FOR A CONSTANT WT. OF AIR.

P = ABS. PRESS. X 144 V = SPESIFIC VOL. = CU. FT. OCCUPIED BY 1 LB. OF AIR.

TEMPERATURE, PRESSURE, VOLUME TABLE FOR AIR

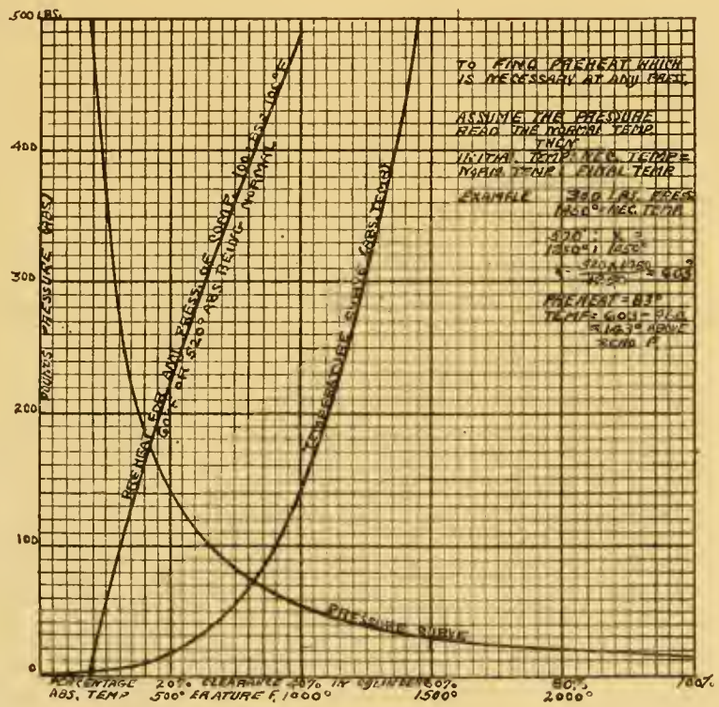
LINE NO.	ABSOLUTE PRESS.	ABSOLUTE TEMP.	GLASS. TEMP.	PER CENT. VOLUME	CONTT. TEMP.	% VOL. CORRESP.	TEMP. INCHE.	AD. COMP. VOL. INC.	SP. VOL. AD. COMP.
1	14.7	520.6	59.9	1.000	59.9	1.0000			13.090 CUFT
2	15.	523.5	62.8	98.57	59	9800	2.9	0143	12.925 "
3	20.	568.1	107.4	8220	"	7357	44.	1837	10.498 "
4	25	606.7	146.	6853	"	5880	39	1167	8.970 "
5	30.	639.4	178.7	6019	"	4900	32.	0834	7.878 "
6	35	666.1	205.4	5394	"	4200	27.	0625	7.061 "
7	40	694.7	234.	4904	"	3675	28	0490	6.419 "
8	45	718.8	258.	4510	"	3266	24.	0394	5.904 "
9	50	741.	280.3	4184	"	2940	22.	0226	5.477 "
10	55	761.6	300.9	3909	"	2672	21.	0275	5.118 "
11	60.	780.9	320.2	3675	"	2449	20.	0234	4.810 "
12	65	799.1	338.4	3471	"	2262	18.	0204	4.544 "
13	70	816.4	355.7	3293	"	2100	17.	0178	4.311 "
14	75	832.7	372.	3135	"	1960	16.	0148	4.103 "
15	80	848.4	387.7	2994	"	1837	16.	0141	3.920 "
16	85	863.4	402.7	2868	"	1729	15.	0126	3.754 "
17	90.	877.6	417.1	2754	"	1634	15.	0114	3.605 "
18	95	891.4	430.7	2650	"	1548	14.	0104	3.469 "
19	100.	904.7	444	2555	"	1470	13.	0095	3.344 "
20	125.	964.9	504.2	2179	"	1176	60.	0376	2.853 "
21	150.	1017.0	556.3	1914	"	9799	52.	0265	2.506 "
22	175.	1063.2	602.5	1715	"	8400	46.	0199	2.245 "
23	200.	1105.9	645.2	1561	"	735	43.	0154	2.044 "
24	225.	1143.0	682.3	1431	"	653	37.	0130	1.877 "
25	250.	1178.	717.3	1331	"	588	35.	0100	1.742 "
26	275	1211.	750.3	1243	"	535	33.	0088	1.628 "
27	300	1241.7	781.	1171	"	491	31.	0078	1.533 "
28	400	1345.5	884.8	953	"	368	103.0	0218	1.247 "
29	500	1439.	978.3	813	"	249	93.5	0140	1.064 "
30	600	1516.3	1055.6	714	"	245	77.3	0099	.935 "
31	700	1576.3	1115.6	636	"	210	60.	0078	.8321 "
32	800.	1647.8	1187.1	581	"	184	52.	0075	.7612 "
33	900.	1705.	1244.3	535	"	163	57.	0046	.7001 "
34	1000.	1756.	1295.3	496	"	147	52.	0039	.6490 "
35									

John F. Wentworth
June 8th 1914.

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Thermodynamics of the Marine Oil Engine," by John F. Wentworth, Esq., Visitor.

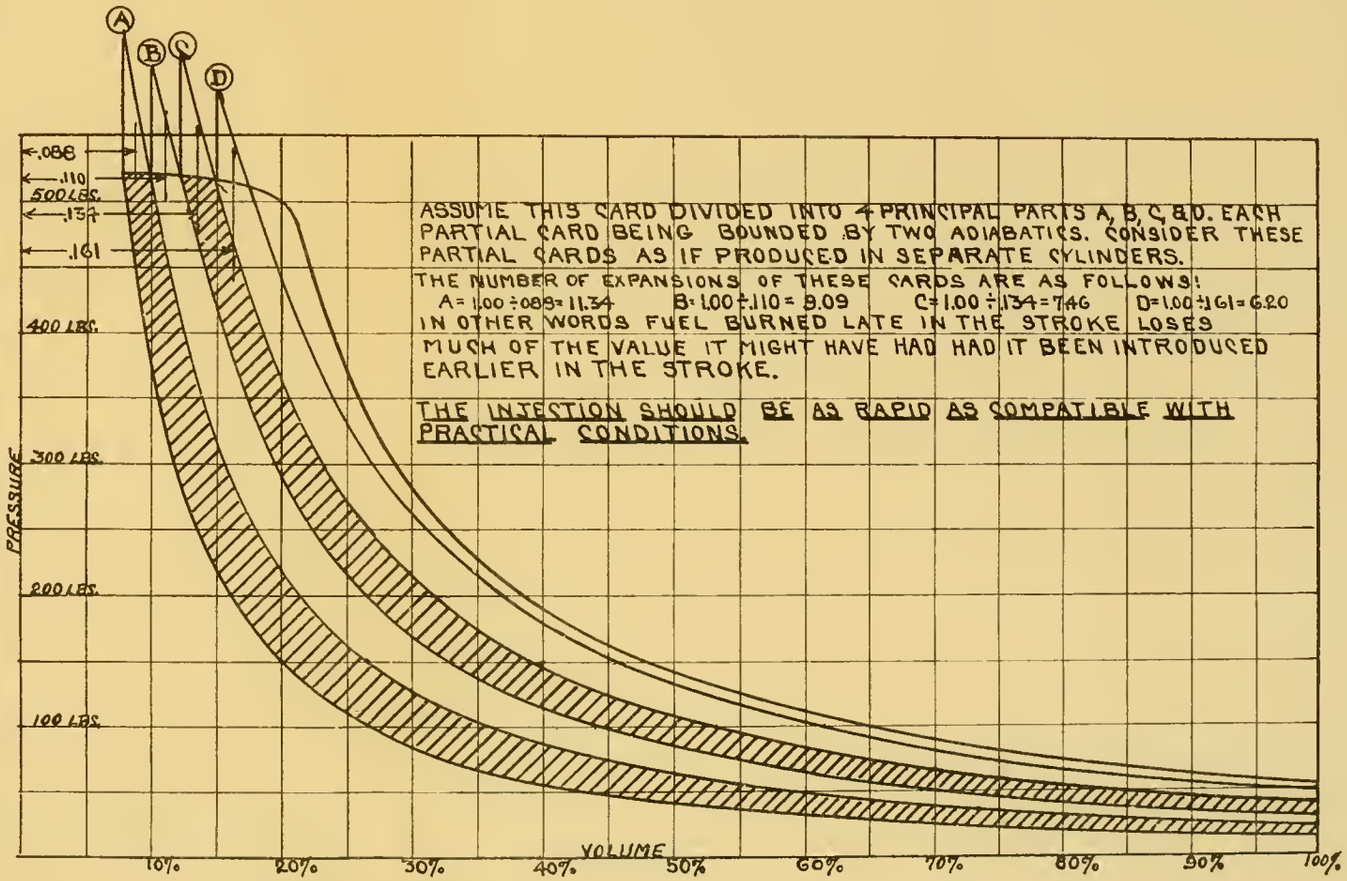
PREHEAT



NOTE:

TO USE PREHEAT CURVE, FOLLOW THE VOLUME LINE FOR PRESSURE DESIRED AND READ FROM CURVE AT INTERSECTION.

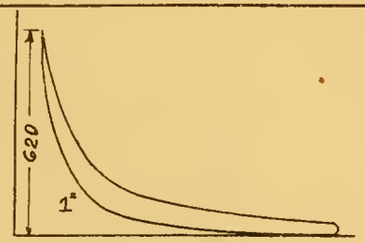
EFFECT OF DIESEL SLOW INJECTION OF FUEL

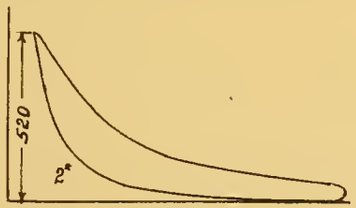


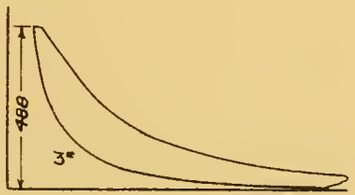
John F. Wentworth
June 17 1914

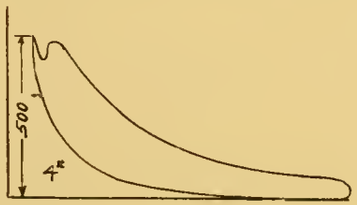
To illustrate paper on "The Thermodynamics of the Marine Oil Engine," by John F. Wentworth, Esq. Visitor.

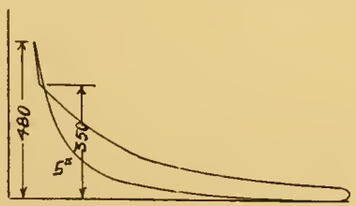
ENGINE DATA

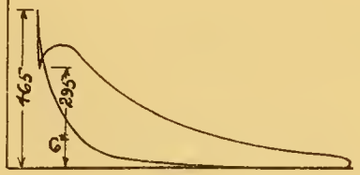


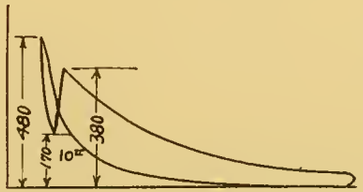


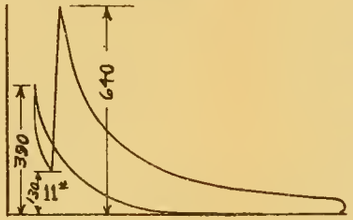


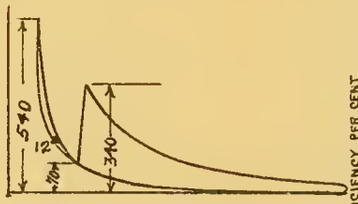


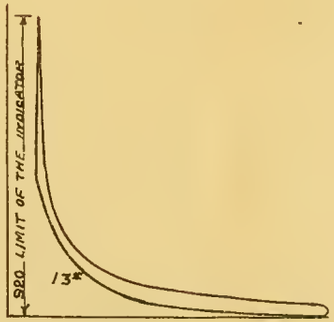












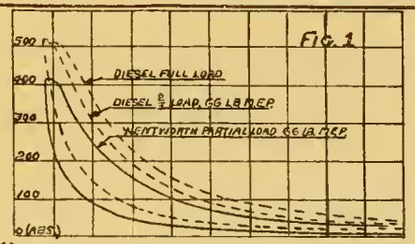
NOTES.

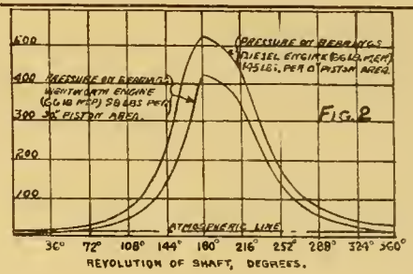
CARDS 1* TO 13 REPRODUCTIONS OF ACTUAL CARDS FROM THE WENTWORTH EXPERIMENTAL ENGINE.

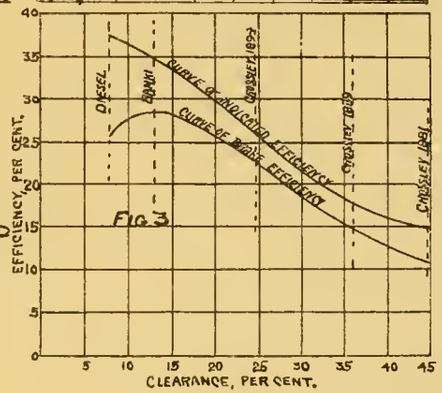
FIGS. 1 & 2 SHOW WENTWORTH PROPOSED METHOD OF GOVERNING & EFFECT ON FRICTION LOSS.

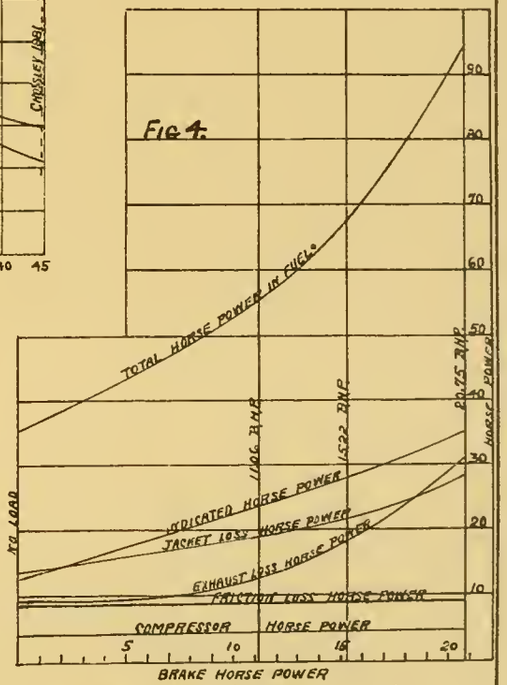
FIG. 3. SHOWS EFFECT OF COMPRESSION ON EFFICIENCY.

FIG. 4. SHOWS VARIATION OF LOSSES WITH DIFFERENT LOADS. THIS FIG. IS CONSTRUCTED FROM PROF. DENTON'S TEST ON A 20 H.P. DIESEL, IN 1898. NOTE THE FACT THAT FRICTION AND COMPRESSOR LOSSES ARE PRACTICALLY CONSTANT AT ALL LOADS.







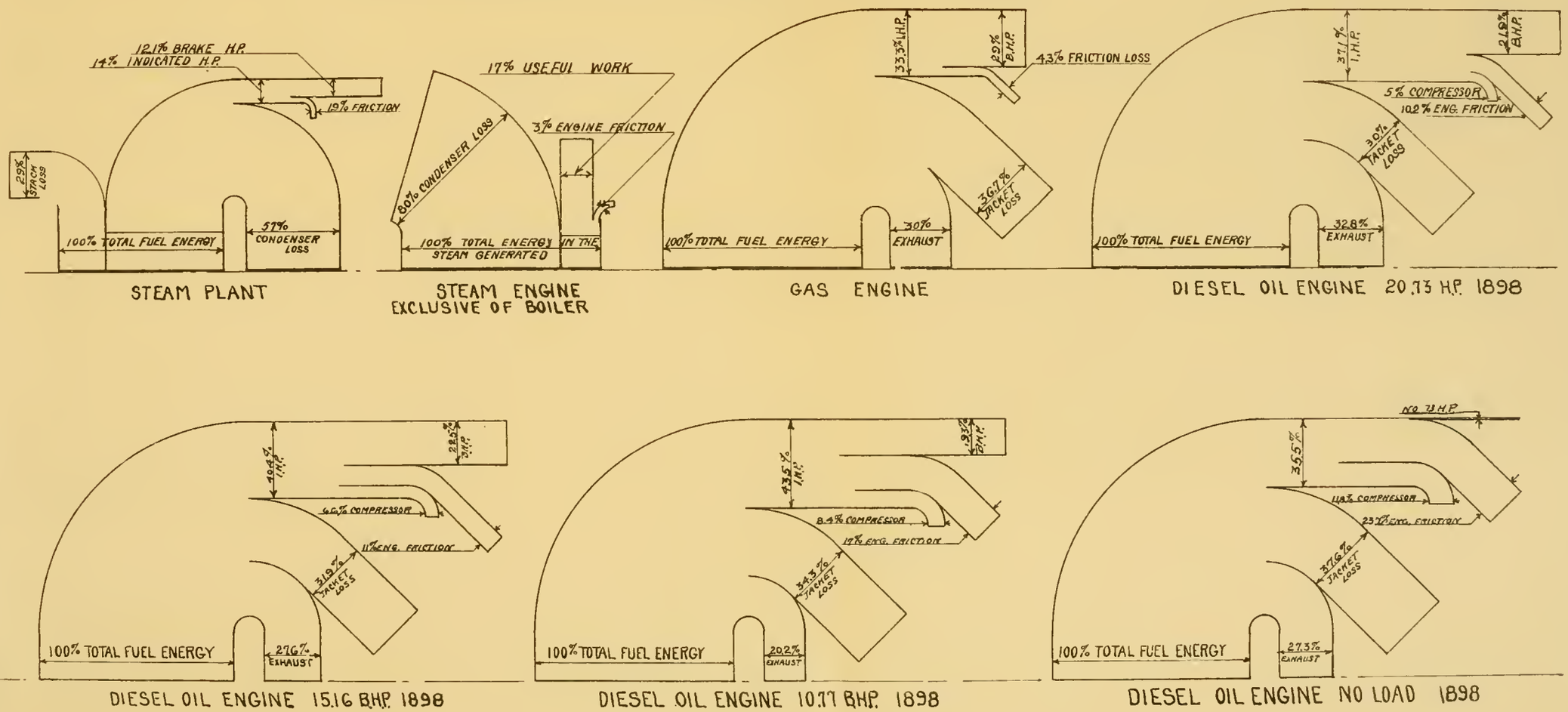


John F. Wentworth
June 12 1914.

THE NORRIS PETERS CO., WASHINGTON, D.

To illustrate paper on "The Thermodynamics of the Marine Oil Engine."
by John F. Wentworth, Esq., Visitor.

HEAT BALANCES FOR VARIOUS TYPES OF ENGINES



John F. Wentworth
June 1st. 1914

THE HORNIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "The Thermodynamics of the Marine Oil Engine," by John F. Wentworth, Esq. Visitor.

SUGGESTION FOR A THERMO PLANT

LEGEND

IN U.S. PATENT 542,846 WE FIND THE AMBITION OF DIESEL WAS TO PRODUCE AN UNJACKETED ENGINE. HIS SUCCESSFUL FAILURE IS NOW CURRENT HISTORY.

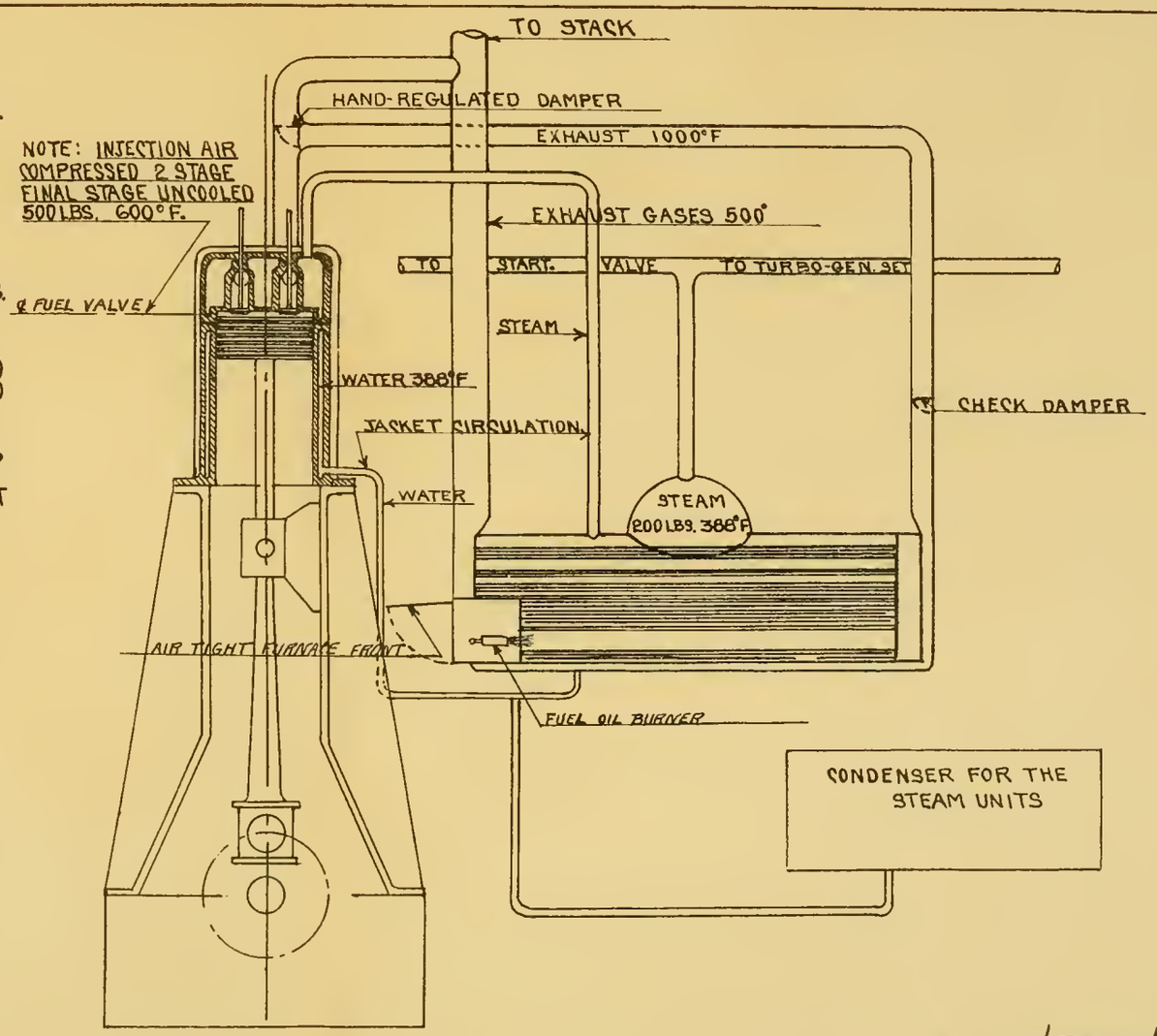
IN THIS SUGGESTED THERMO-PLANT THERE ARE SHOWN COMBINED IN NEW RELATIONS SOME OLD ELEMENTS. THEY ARE AS FOLLOWS:

1 USE OF HOT WATER AS A MEANS FOR STORING ENERGY. (SEE FIRELESS LOCOMOTIVE OF PARIS TUNNEL.)

2. EXHAUST GASES OF A GAS-ENGINE FOR GENERATION OF STEAM. (RECENT TEST 2 IBS. WATER EVAPORATED AT 200 LBS. PRESSURE PER B.H.P. DEVELOPED IN GAS-ENGINE.)

NEW ELEMENTS.

1 LOW PRESSURE OF COMPRESSION (SEE CARDS SH. 5.)
2 INCREASED PRESSURE FROM FUEL INJ. (" " " 5.)
3 COOLING CYLINDER BY EVAPORATION OF WATER IN JACKET. (NO PRECEDENT)
4. CYLINDER LAGGED TO PREVENT RADIATION LOSS. (THIS IS TO A GREAT DEGREE FOR COMFORT OF ENGINEERS.)
5. HIGH TEMPERATURE INJECTION AIR. (NO PRECEDENT SEE SHEET NO. 3



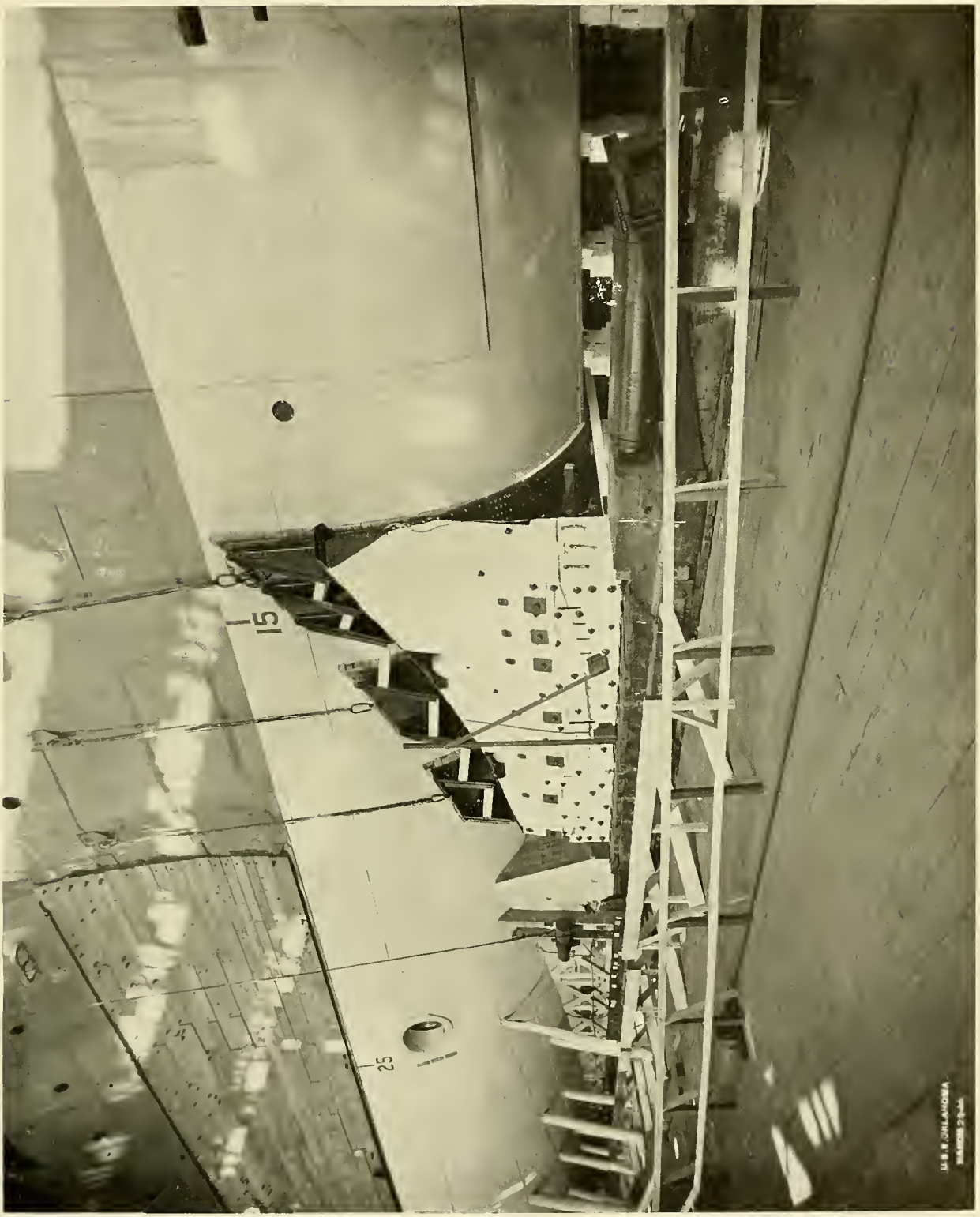
John F. Wentworth
June. 17 1914

THE NORRIS PETERS CO., WASHINGTON, D. C.

To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.

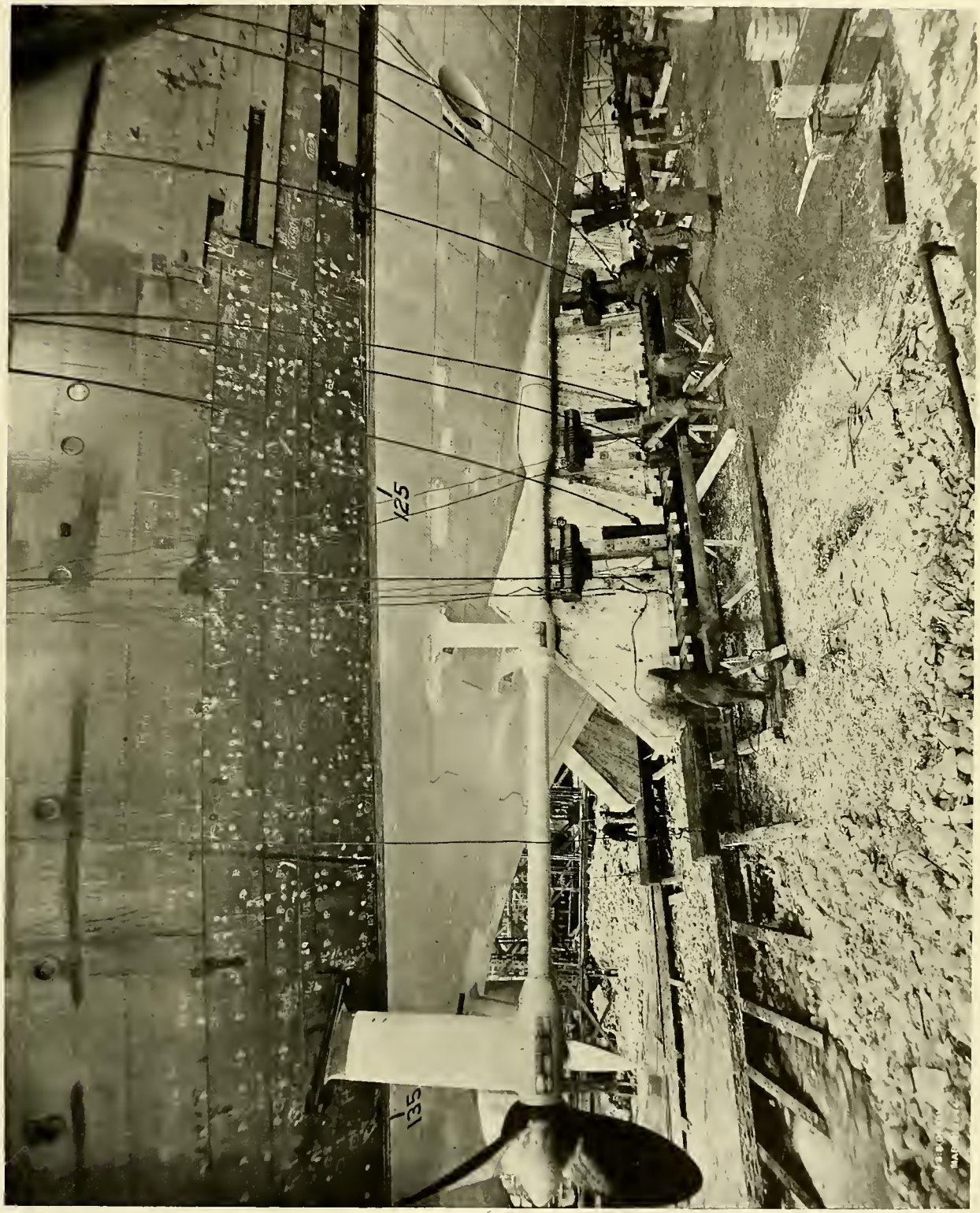
U. S. S. Oklahoma. Launched March 23, 1914.

To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Taveresey, U. S. N., Member.



U. S. S. Oklahoma. Launching Arrangements—Fore Poppets.

To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.

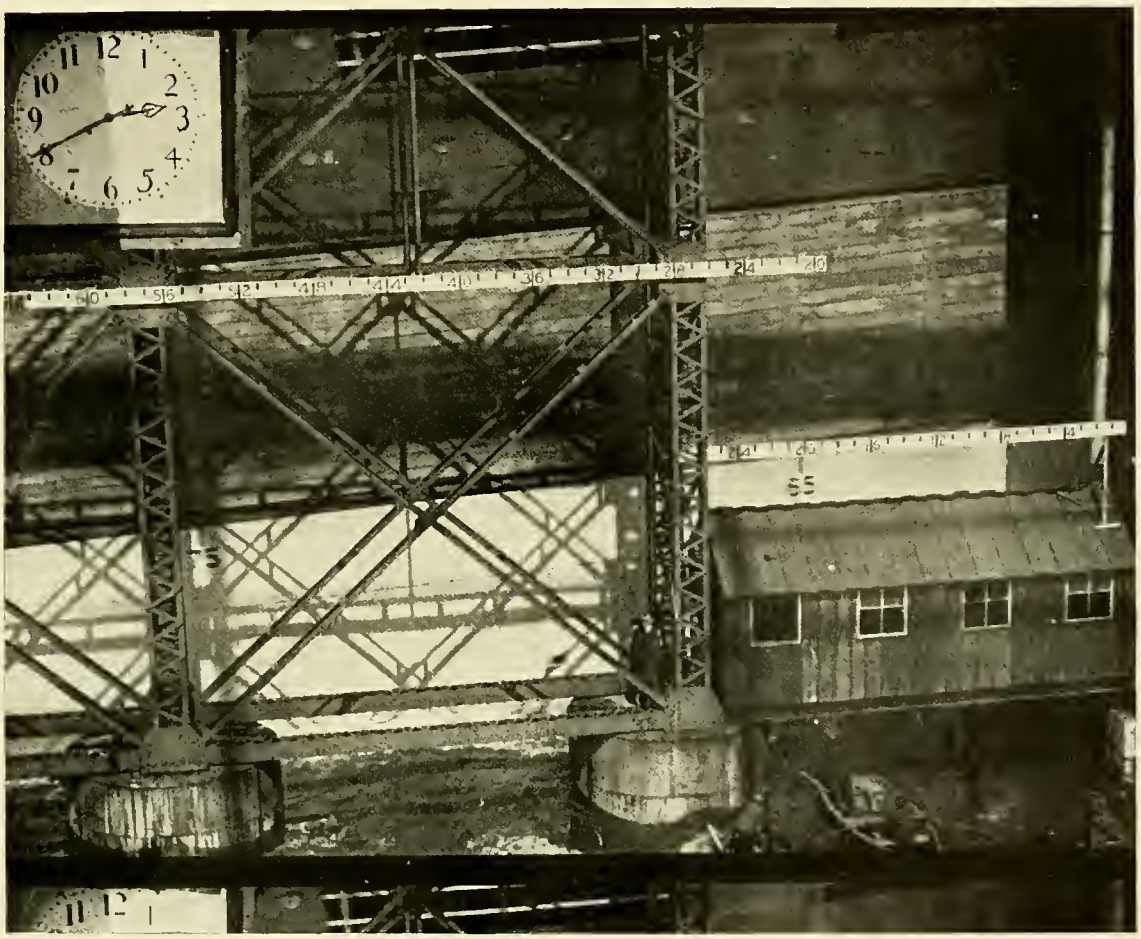


U. S. S. Oklahoma. Launching Arrangements—After Poppets.

To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.

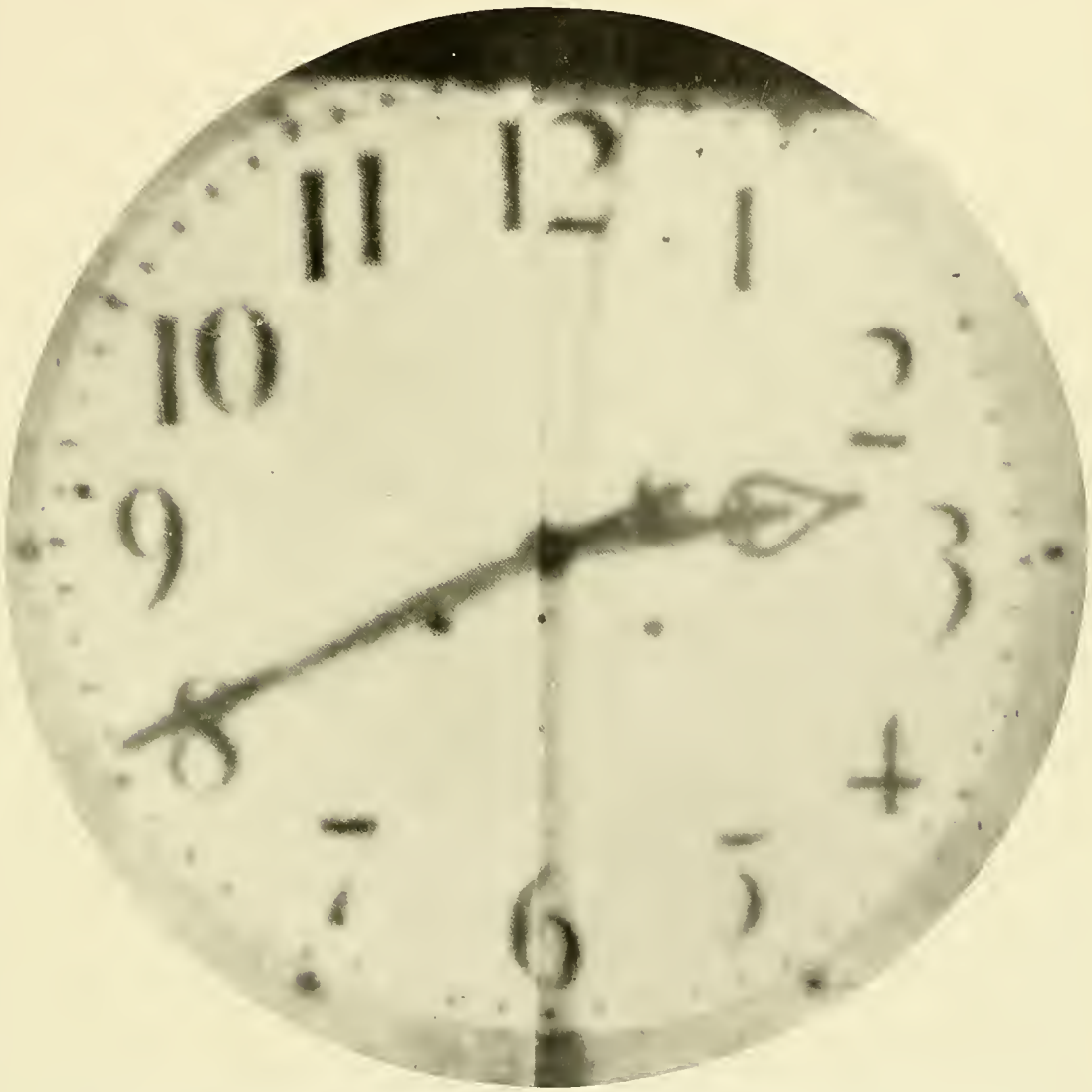
SECTION OF MOVING PICTURE FILM, REPRODUCED EXACT SIZE.

To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.



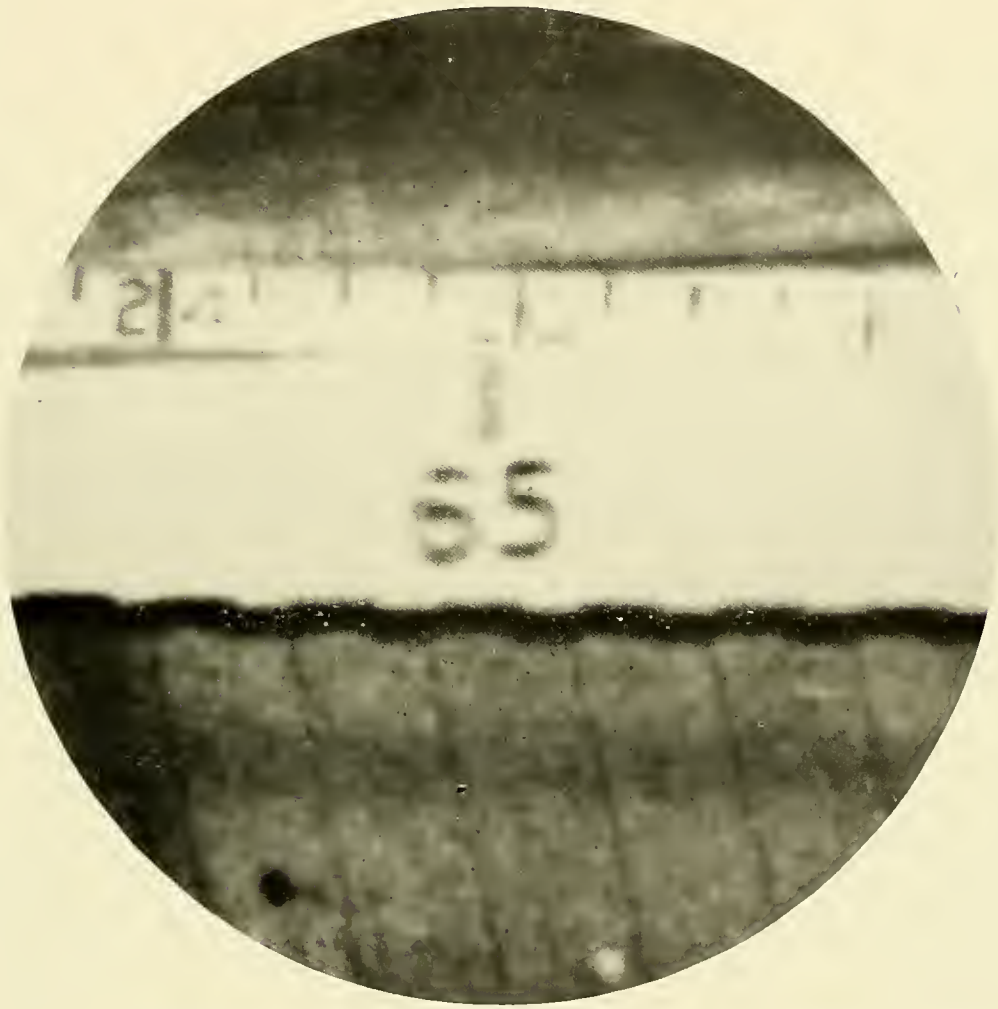
SECTION OF MOVING PICTURE FILM, MAGNIFIED SIX DIAMETERS.

To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.



Clock Face from Plate No. 32, Magnified Thirty-One Diameters to Show Appearance Under the Reading Microscope.

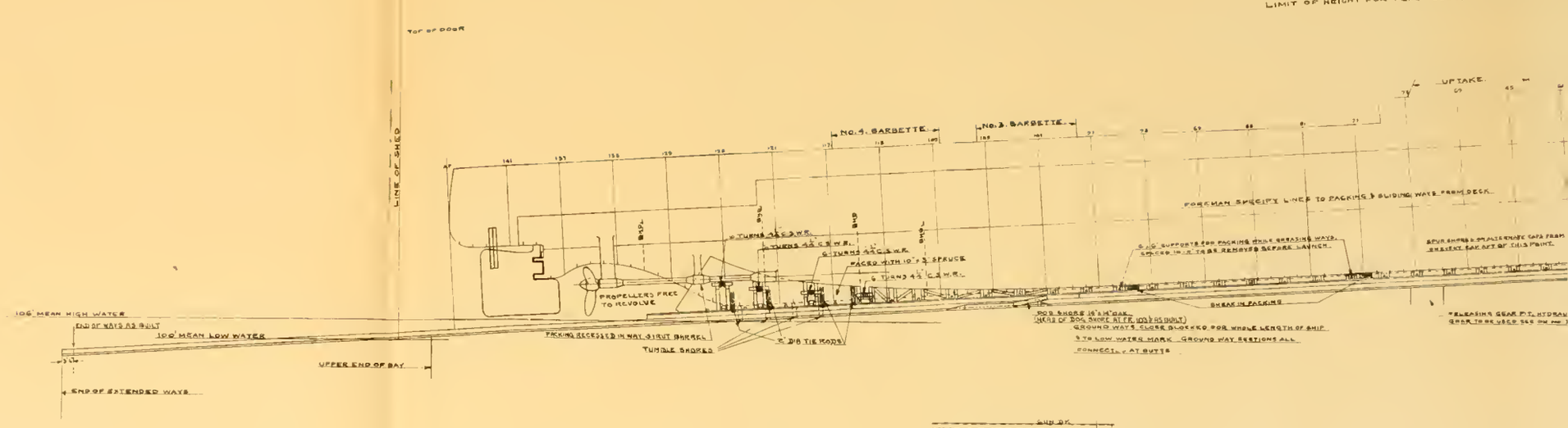
To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.

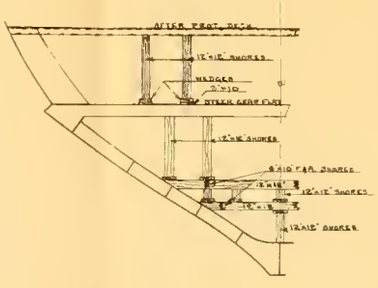


Scale and Station 65 from Plate No. 32, Magnified Thirty-One Diameters to Show Appearance Under the Reading Microscope.

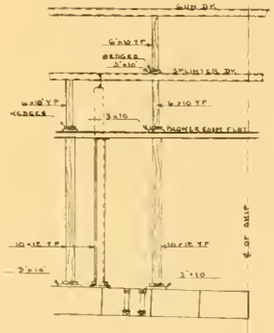
To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.

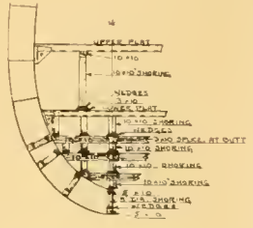
To Show a Suggested Arrangement of Clock and Scale.





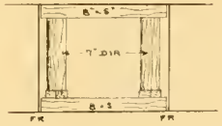
TYPE OF SHORING FRS. 123-126 INCL



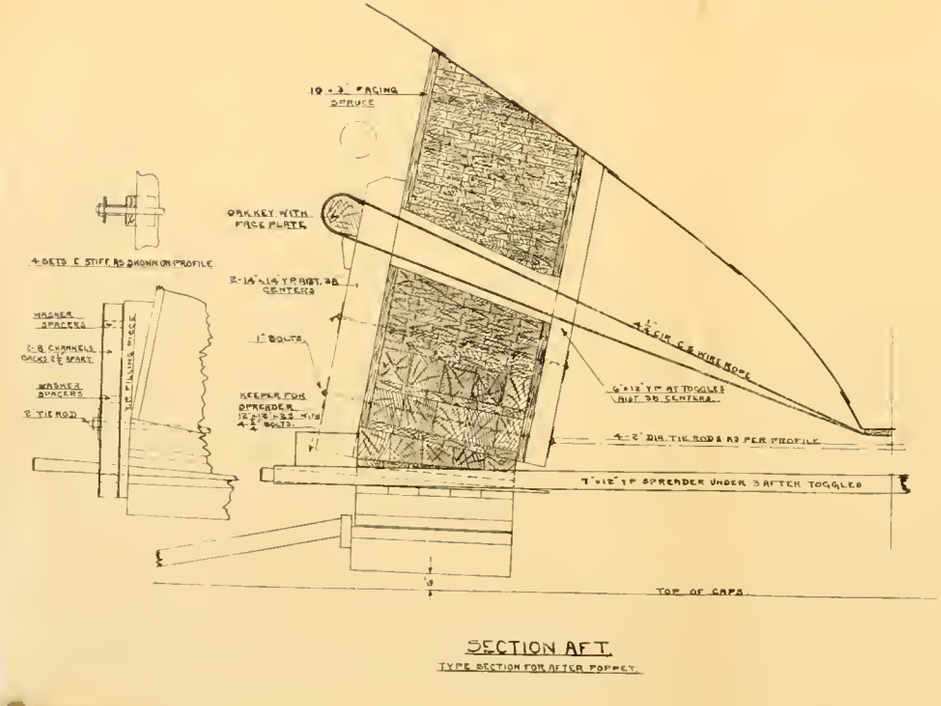


SECTION THRO' FORE POPPET.
SHORING ABOVE L. FLAT ON FR 15 TO 19 INCLUSIVE
SHORING BELOW L. FLAT ON FR 4 TO 18 INCL AND ON HALF FRAMES

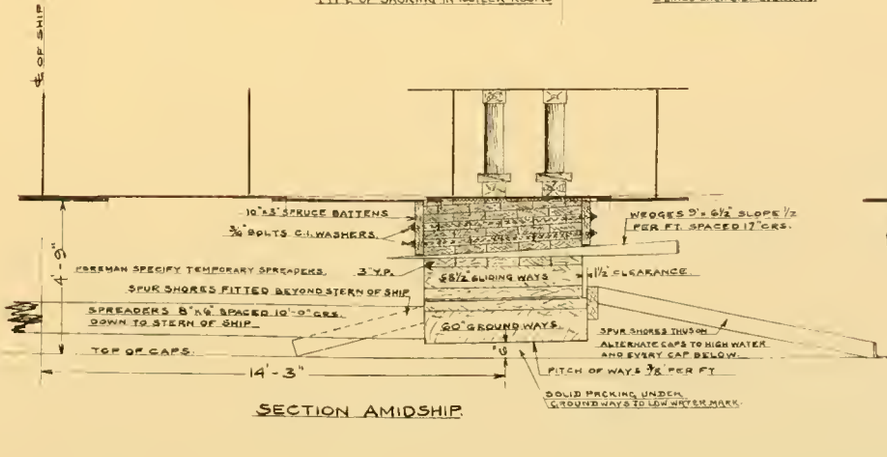
TYPE OF SHORING IN BOILER ROOMS



SHORING IN DBL BOTTOM
FRAMES 84-104
2 LINES EACH SIDE OVERWAYS.

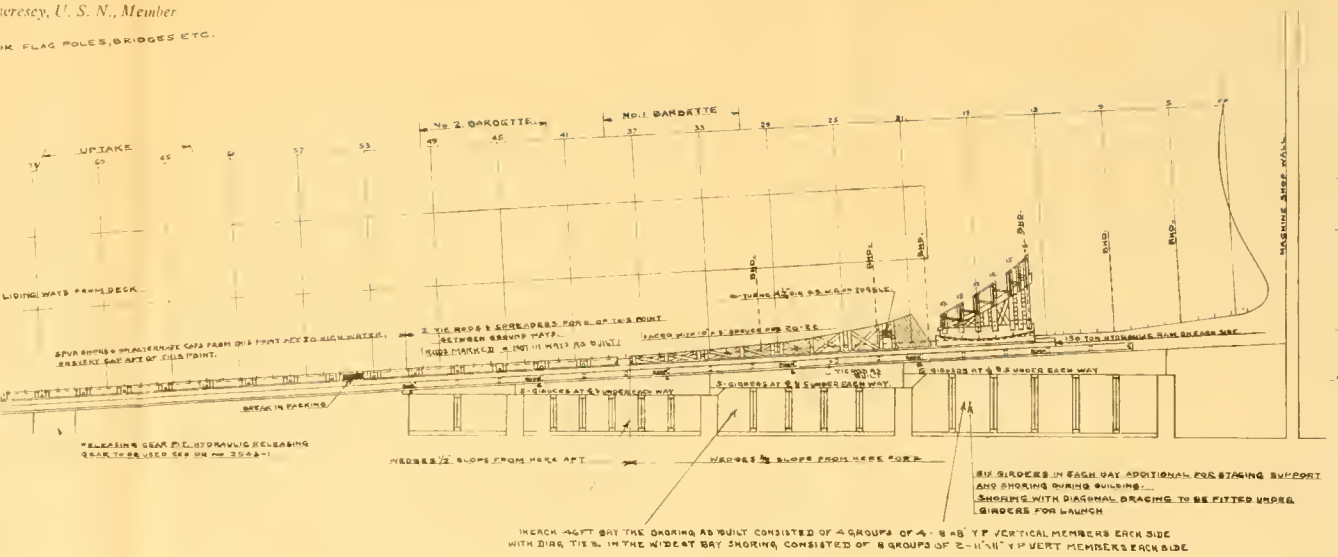


SECTION AFT.
TYPE SECTION FOR AFTER POPPET.



SECTION AMIDSHIP

K FLAG POLES, BRIDGES ETC.



INTERNAL SHORING

INNER BOTTOM:- GENERALLY A DOUBLE LINE OF SHORING ON EACH SIDE AS SHOWN, FROM FRS 24 TO 104. INNER LINE ABOUT 13'-9" AND OUTER LINE ABOUT 15'-9" FROM ℄.

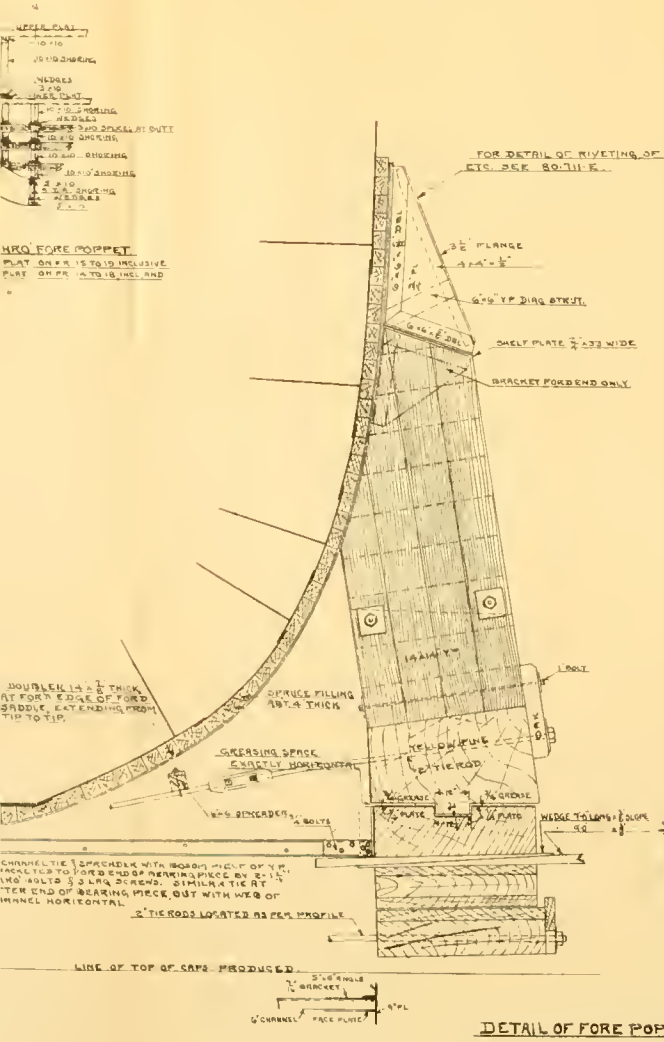
BOILER ROOMS: SHORING PLACED IN EACH BOILER ROOM AS SHOWN IN TYPE SKETCH. SHORING DIRECTLY OVER WAYS CARRIED TO GUN DECK LEVEL. REMAINDER OF SHORING CONTINUED TO SPLINTER DECK ONLY. SHIPS OWN PILLARS WERE IN PLACE.

FORE POPPETT SHORING: FITTED AS SHOWN IN TYPE SKETCH ON EVERY FR & ½ FR FROM 15-19 INCL BELOW LOWER PLAT., & ON FRS. 15 19 ONLY BETWEEN PLATFORMS

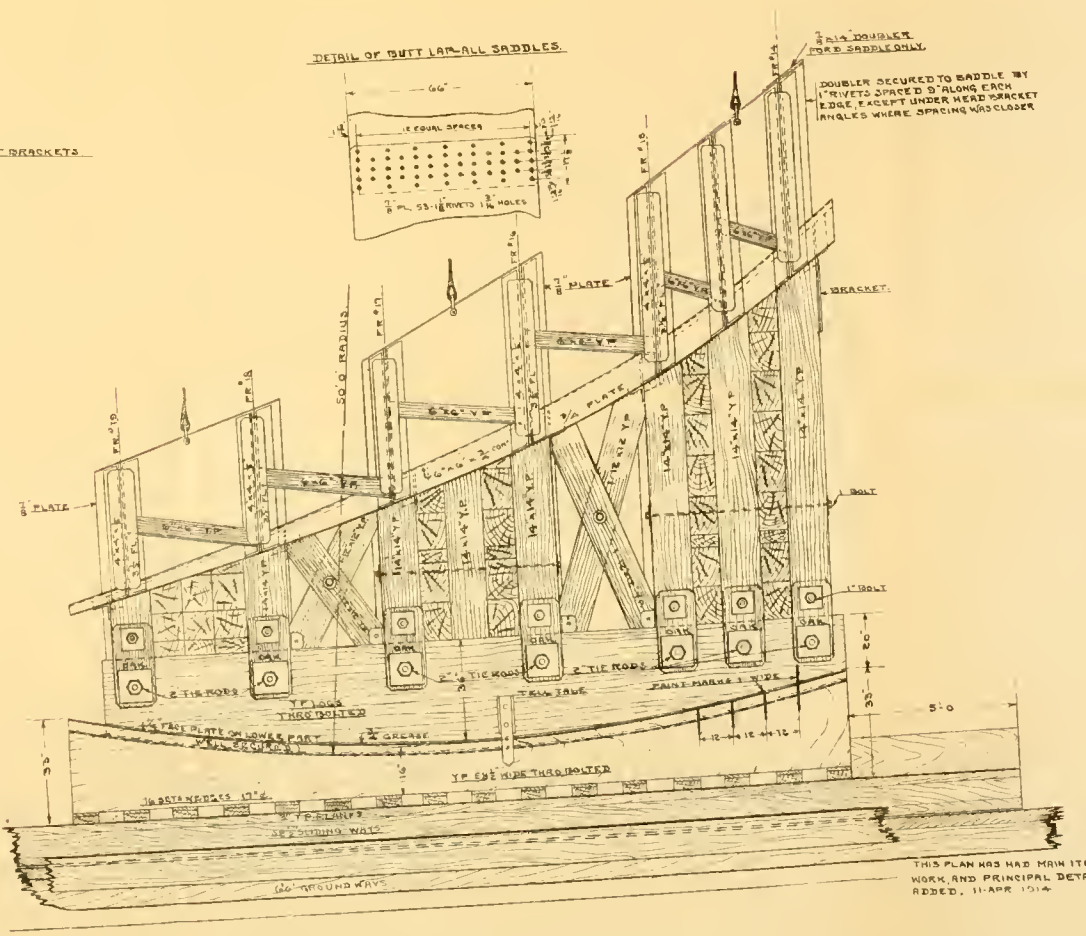
AFTER POPPETT SHORING: FITTED AS SHOWN IN TYPE SKETCH ON FRAMES 123 TO 126 INCLUSIVE, AND CARRIED TO LEVEL OF AFTER SPLINTER DECK.

IN EACH 46FT BAY THE SHORING AS BUILT CONSISTED OF 4 GROUPS OF 4-8"x8" Y.P VERTICAL MEMBERS EACH SIDE WITH DIAG. TIES. IN THE WIDEST BAY SHORING CONSISTED OF 6 GROUPS OF 2-11"x11" Y.P VERT MEMBERS EACH SIDE

BY GIRDERS IN EACH WAY ADDITIONAL FOR STAGING SUPPORT AND SHORING DURING BUILDING.
SHORING WITH DIAGONAL BRACING TO BE FITTED UNDER GIRDERS FOR LAUNCH



DETAIL OF FORE POPPETT.



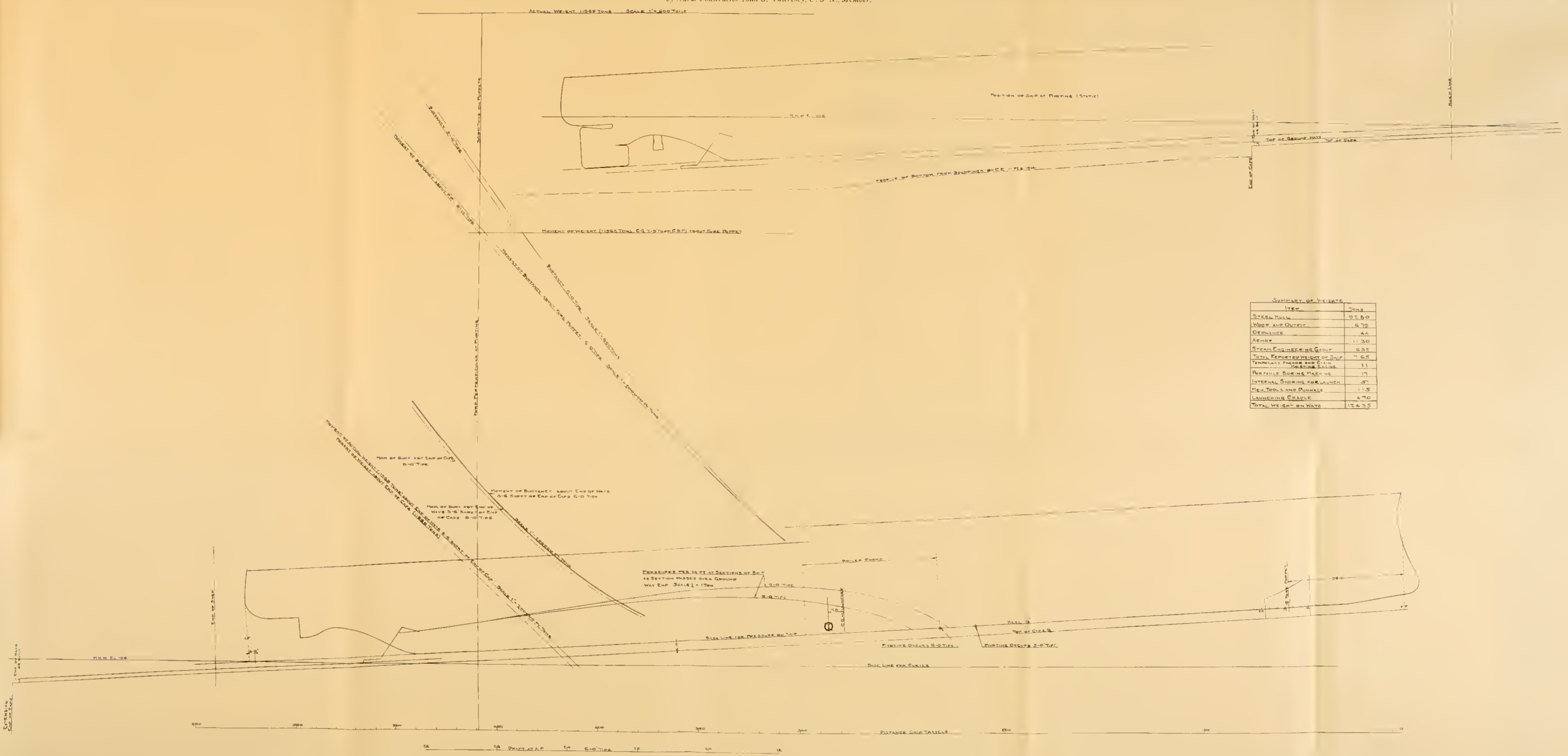
THIS PLAN HAS HAD MAIN ITEMS CHECKED WITH WORK, AND PRINCIPAL DETAILS HAVE BEEN ADDED. 11-APR 1914

FOR OBSERVING BY MOVING PICTURE, ANY ROTATION OF THE FORE POPPET A BLACK STRIPE 1/16 PAINTED DOWN MIDDLE OF UPPER PART, & A STAFF THE PROJECTION OF WHICH LINED UP WITH THE STRIPE, WAS FASTENED TO LOWER PART. ANY DEVIATION FROM ALIGNMENT SHOWS DEGREE OF ROTATION

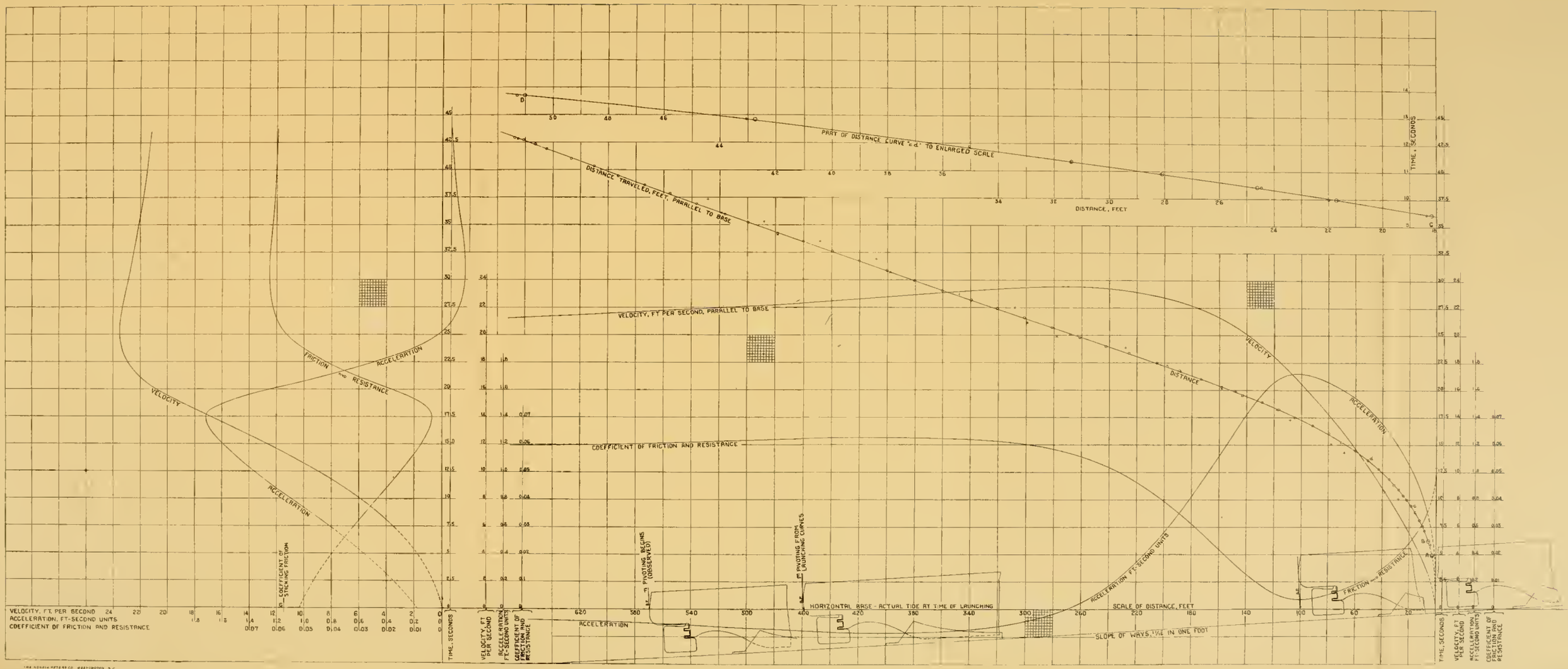
SCALE IN FEET

SCALE IN FEET

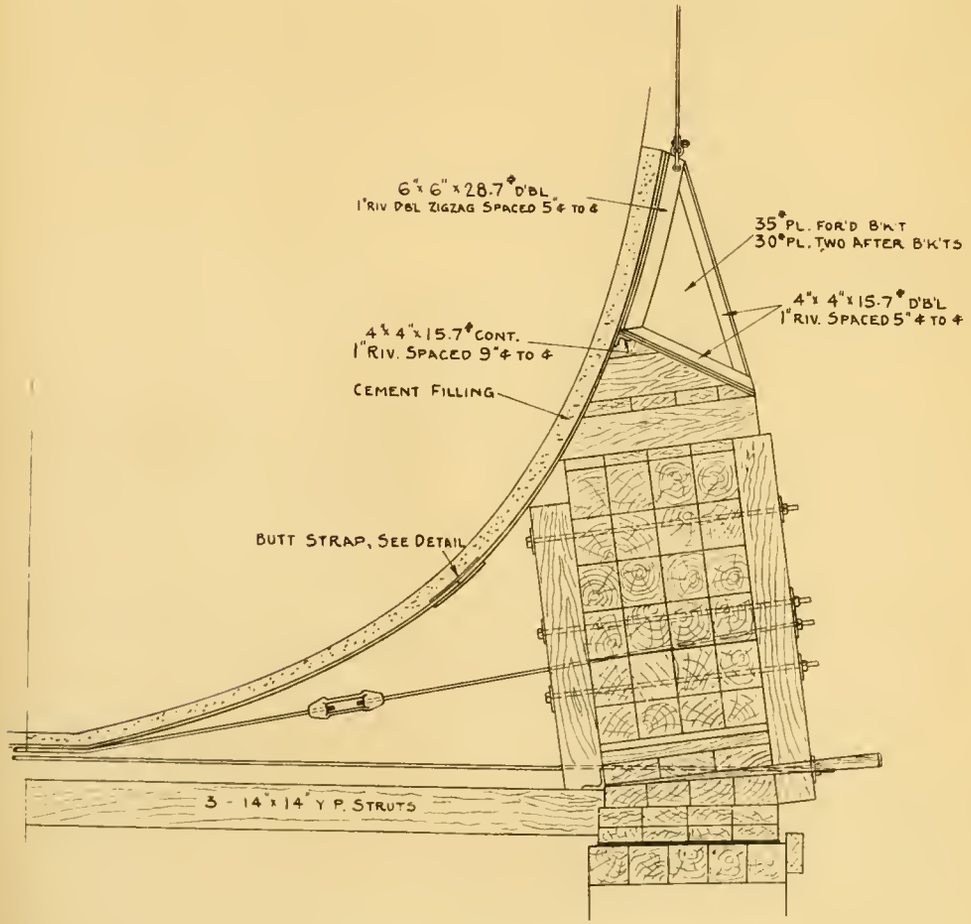
To illustrate paper on "Launching Data for a Battleship"
by Naval Constructor John G. Tawresey, U. S. N., Member.

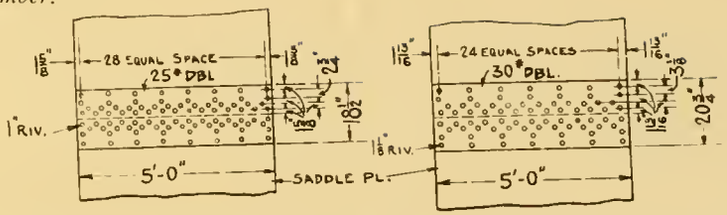


To illustrate paper on "Launching Data for a Battleship,"
by Naval Constructor John G. Tawresey, U. S. N., Member.



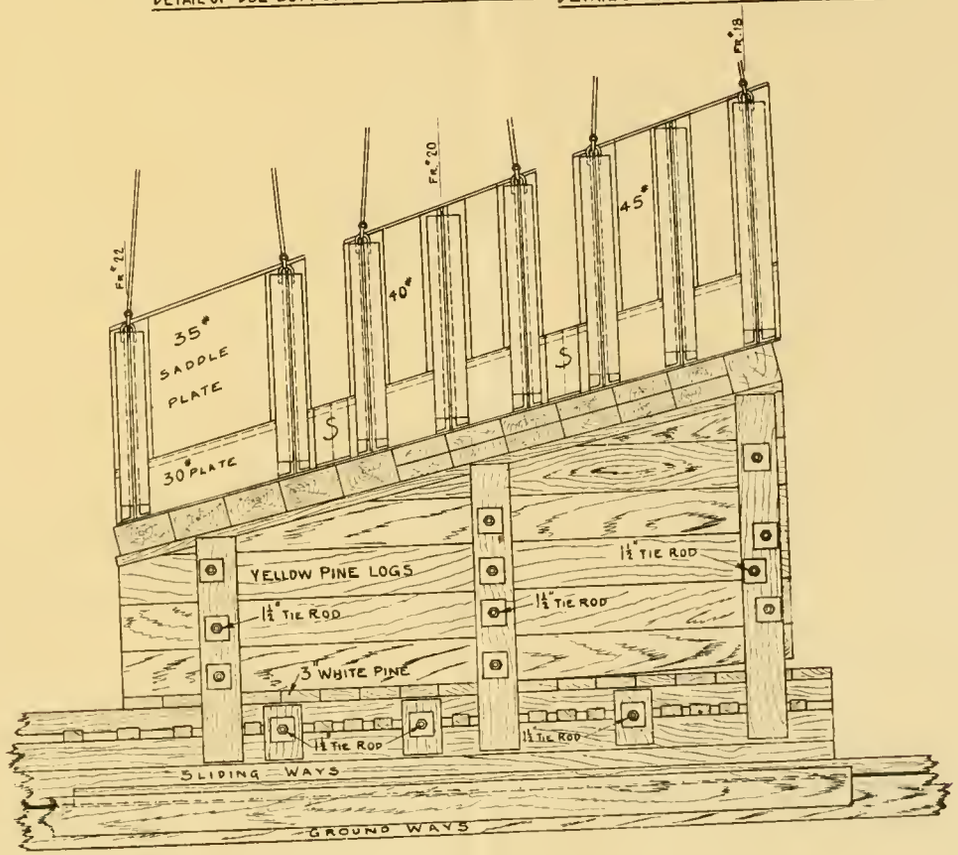
To illustrate discussion by E. C. Bennett, Esq., on paper entitled "Launching Data for a Battleship," by Naval Constructor John G. Tawresey, U. S. N., Member.

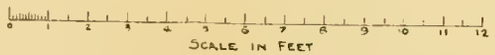




DETAIL OF DBL BUTT STRAPS FOR 40# & 35# PL.

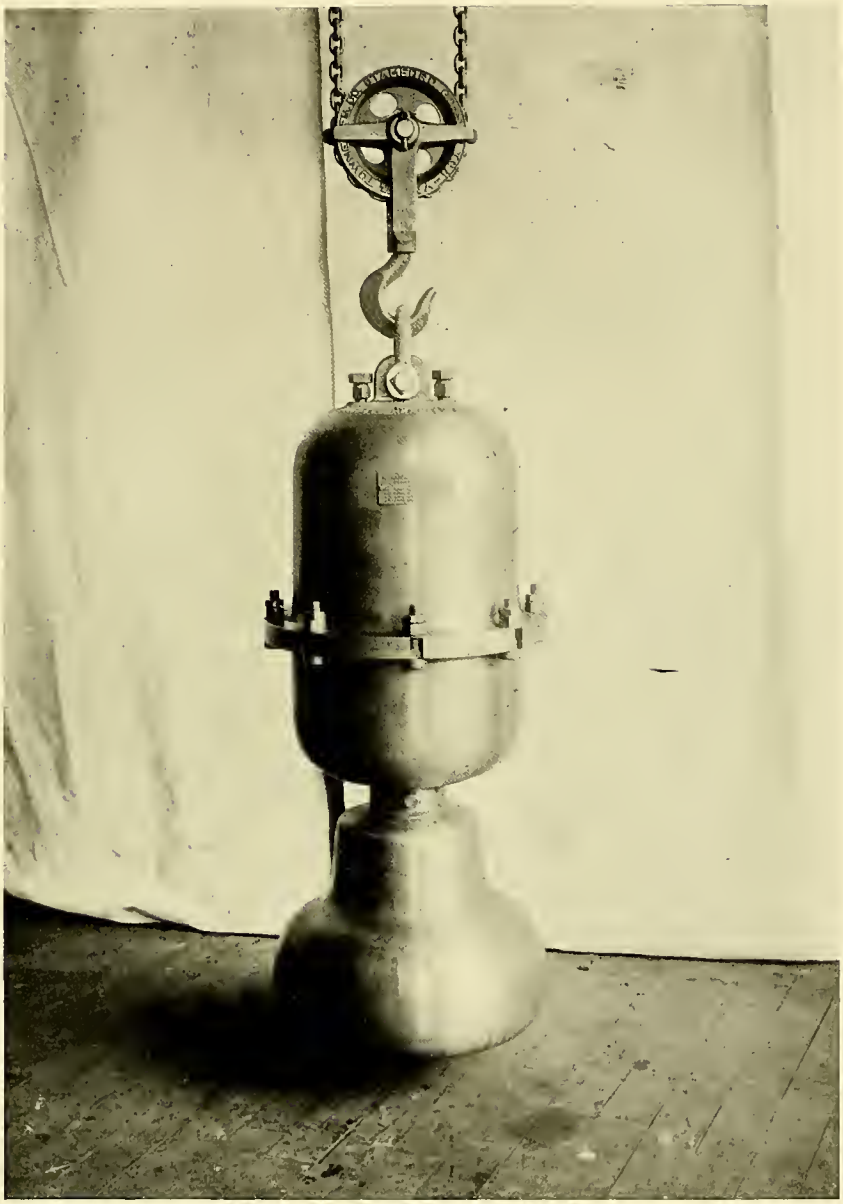
DETAIL OF DBL BUTT STRAPS FOR 45# PL





U.S.S. NEVADA
DETAIL OF FORE POPPET

To illustrate paper on "Recent Developments in Submarine Signaling," by J. B. Millet, Esq., Visitor.

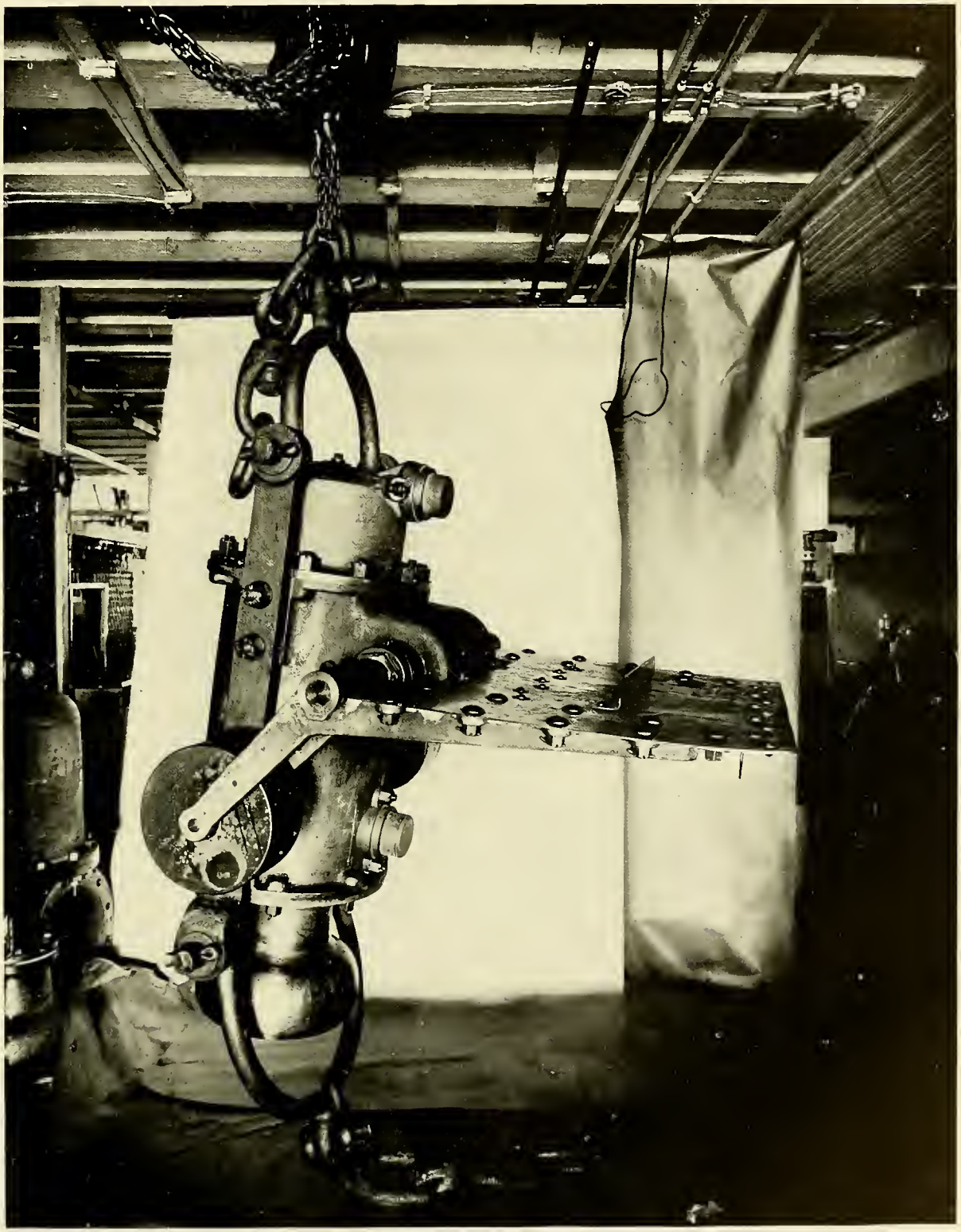


Submarine Bell for Use on Lightships. It is Operated by Compressed Air.

To illustrate paper on "Recent Developments in Submarine Signaling," by J. B. Millet, Esq., Visitor.

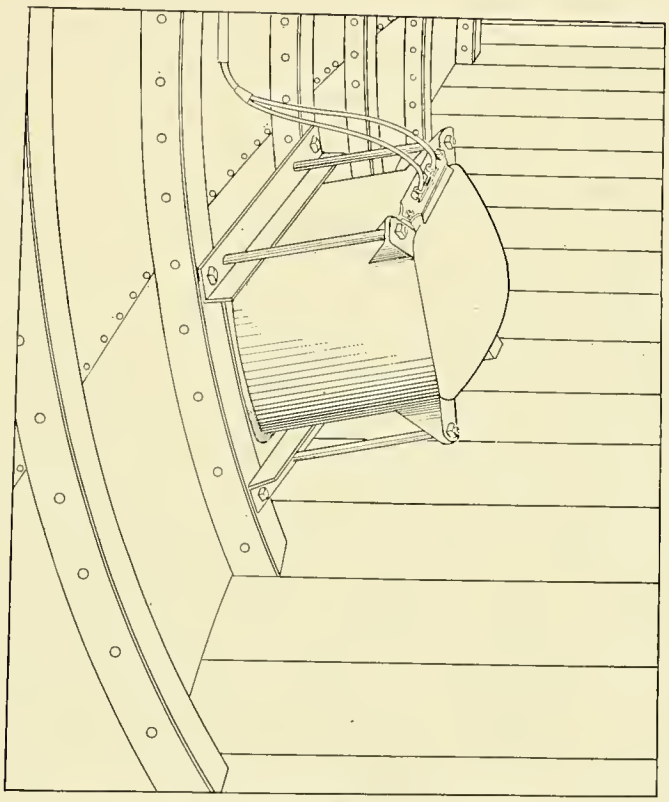
Electric Submarine Bell Supported by a Tripod, to be Operated from the Shore End by Cable.

To illustrate paper on "Recent Developments in Submarine Signaling," by J. B. Millet, Esq., Visitor.



Mechanism and Bell for a Submarine Bell-Buoy. This is Operated by the Motion of the Waves.

To illustrate paper on "Recent Developments in Submarine Signaling," by J. B. Millet, Esq., Visitor.



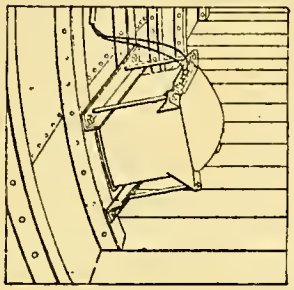
TRANSMITTER TANK

Tank in Which the Transmitters Are Hung. Two of These Are Installed on Board Ship Below the Water-Line, One on Each Side, Well Forward on the Bow.

To illustrate paper on "Recent Developments in Submarine Signaling," by J. B. Millet, Esq., Visitor.

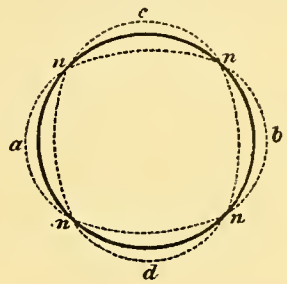
Indicator Box for Ascertaining Direction.

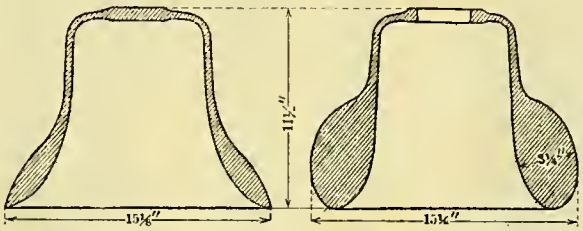
To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.



RECEIVING TANK FIG. 1.

FIG. 3.





Air Bell.
Weight 85 lb.
Vibrations per sec. 350.

Submarine Bell.
Weight 210 lb.
Vibrations per sec { in air 1280 / in water 1215.

FIG. 2.—SKETCH SHOWING DIFFERENCE BETWEEN AIR BELL AND SUBMARINE BELL.

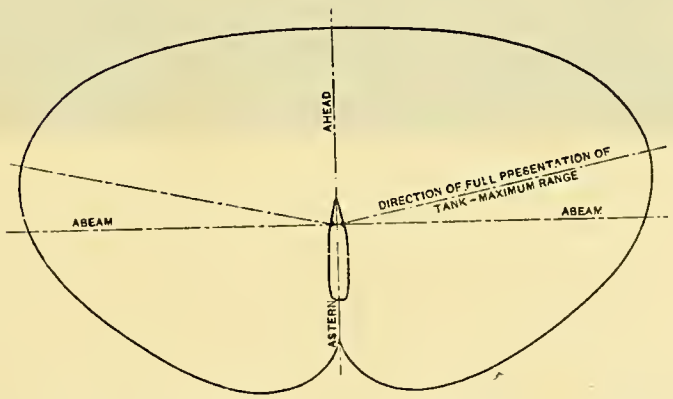


FIG. 4.—SKETCH ILLUSTRATING RELATIVE DISTANCES THE SUBMARINE BELL CAN BE HEARD AT DIFFERENT ANGLES.

To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.

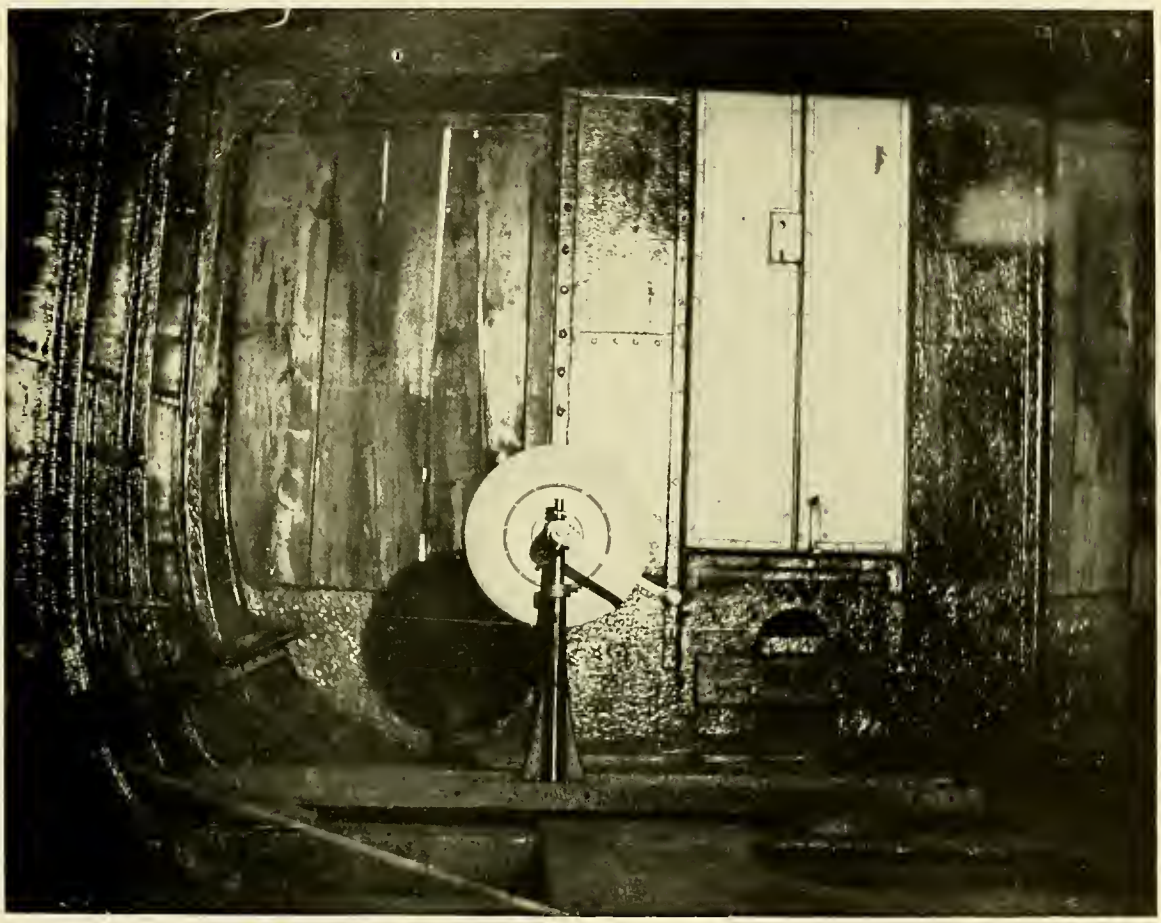


FIG. 5.

To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.

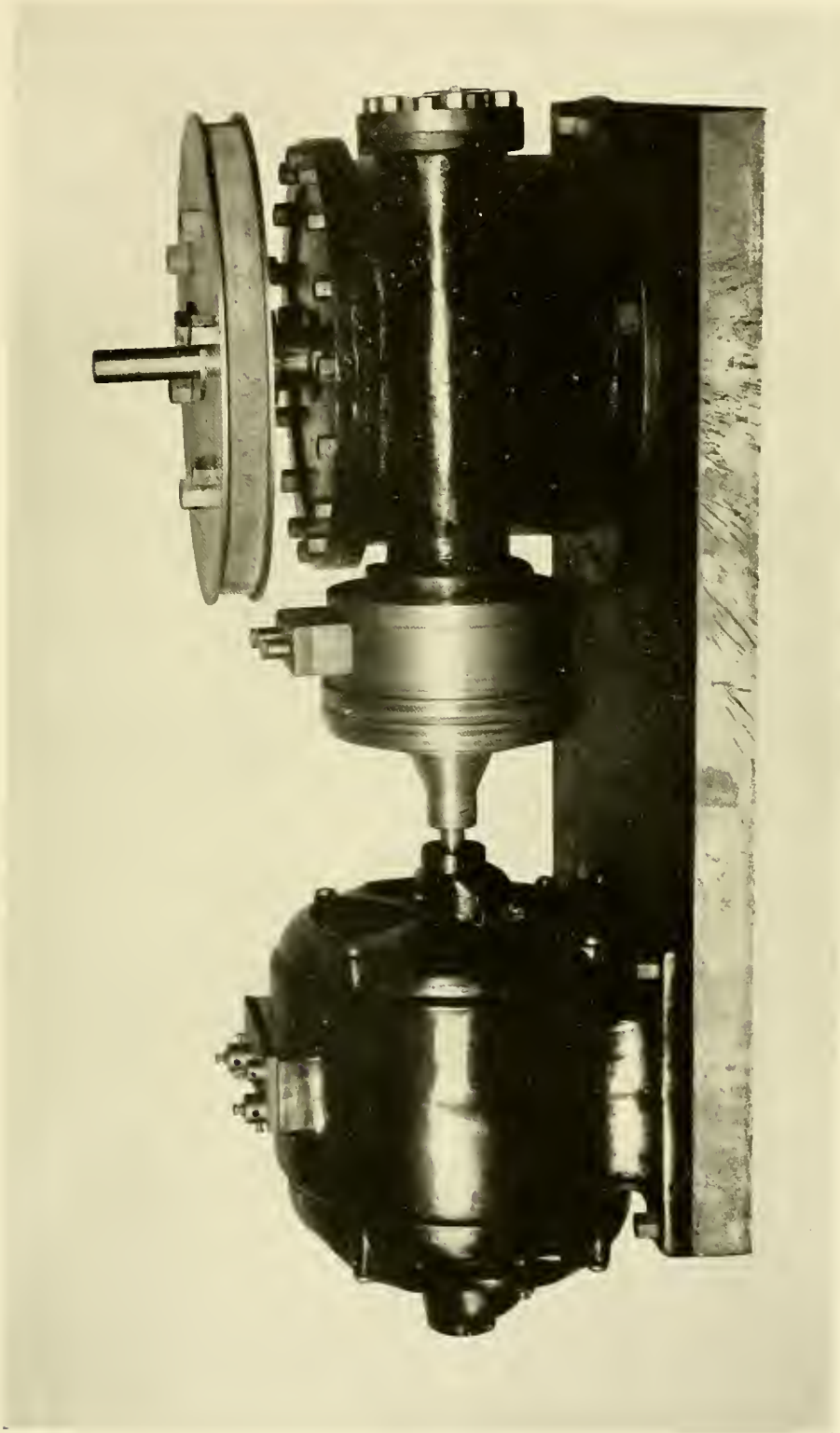


FIG. 6.—½ HORSE-POWER SUBMARINE WIRELESS TRANSMITTING SET.

To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.

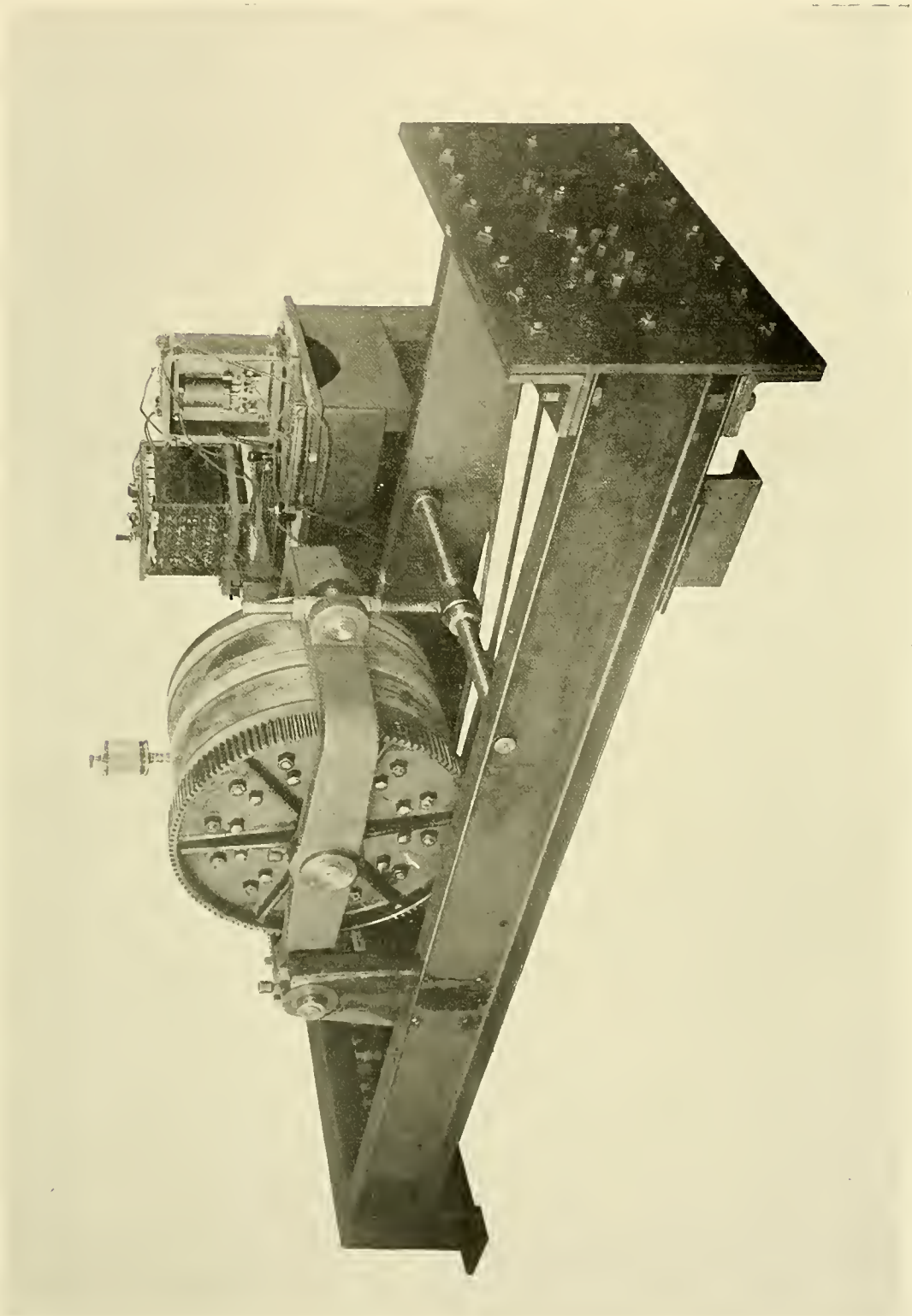


FIG. 7.—3 HORSE-POWER SUBMARINE WIRELESS TRANSMITTING SET.

To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.

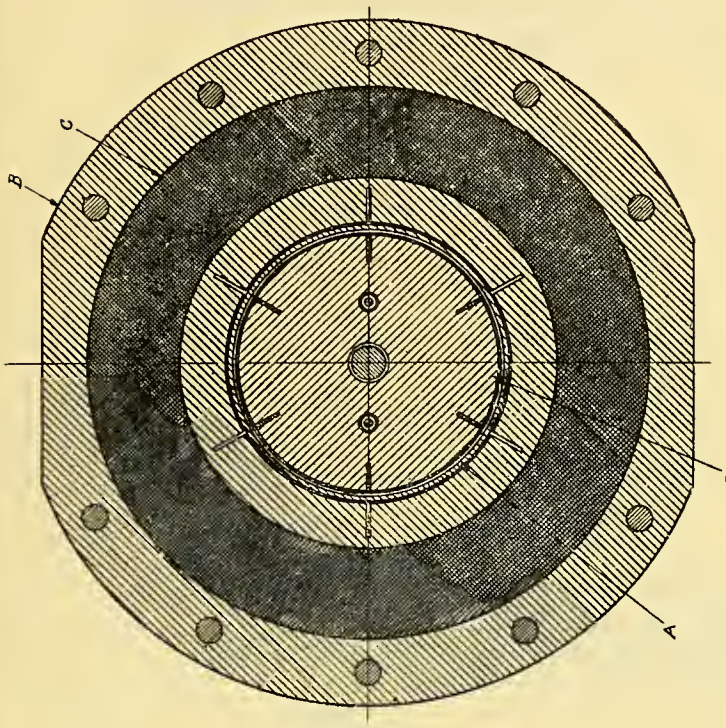
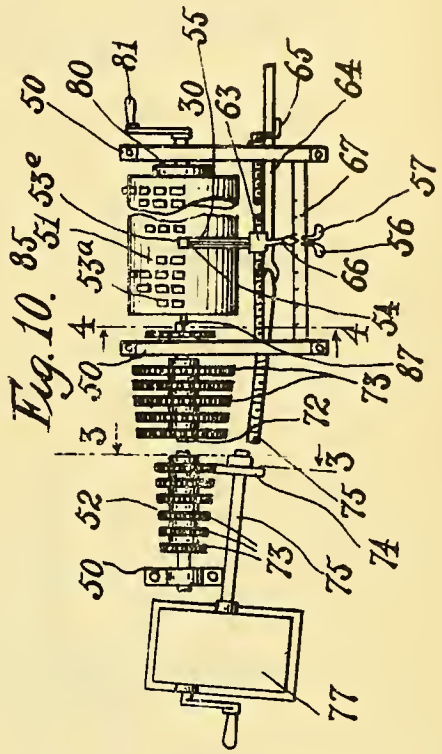


FIG 9. Cross Section of Oscillator.



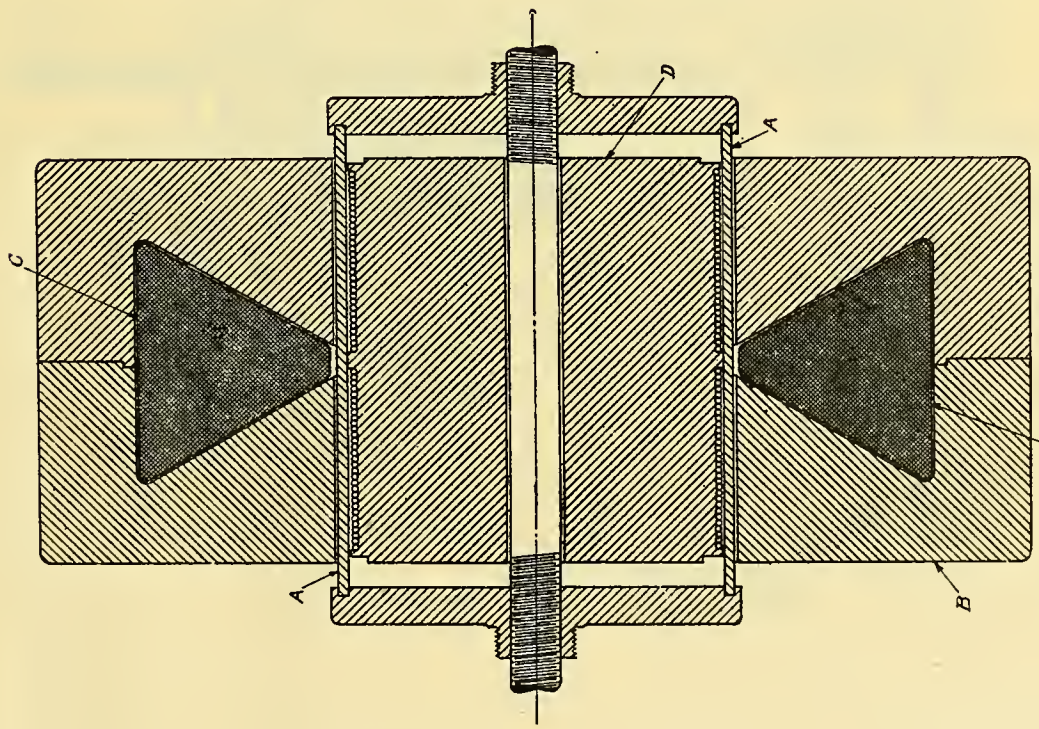


FIG. 8. Longitudinal Section of Oscillator.

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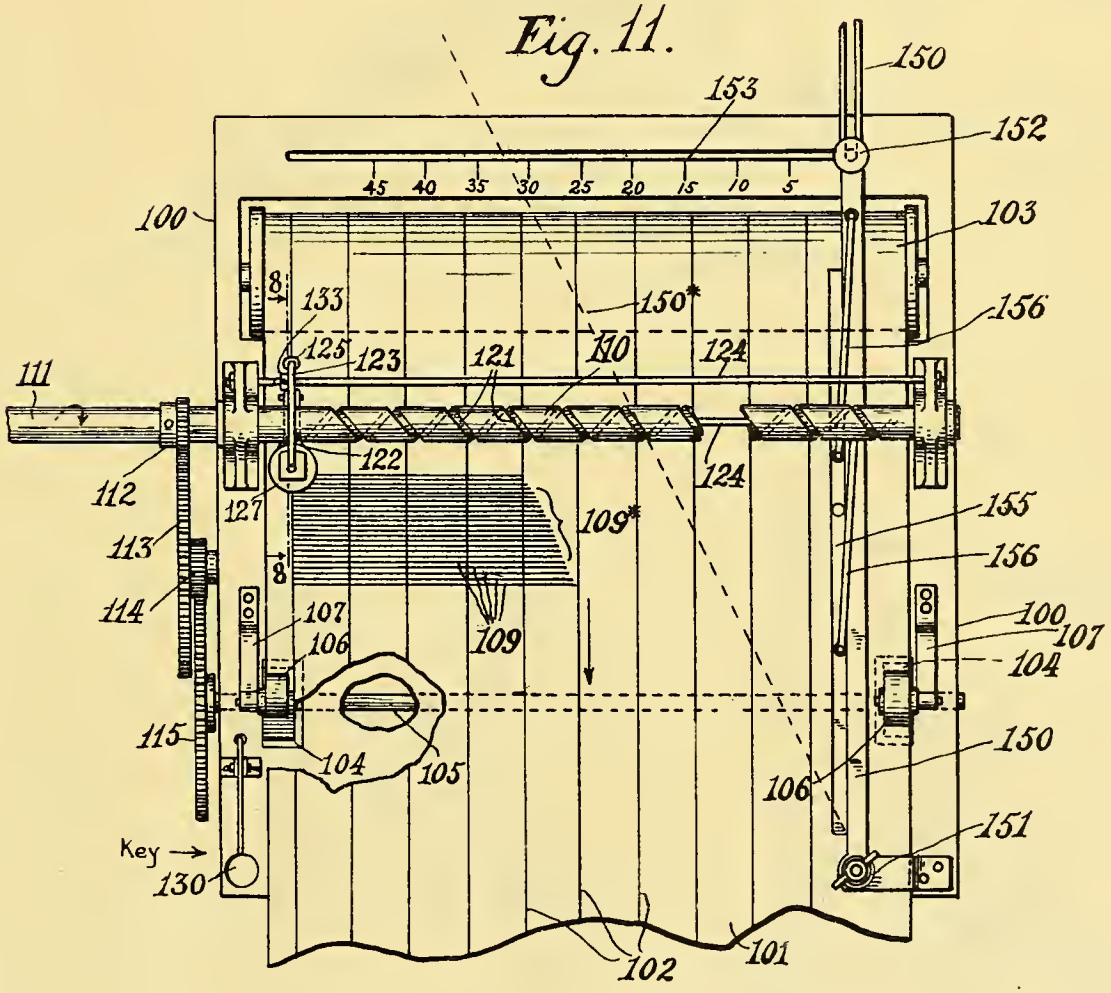
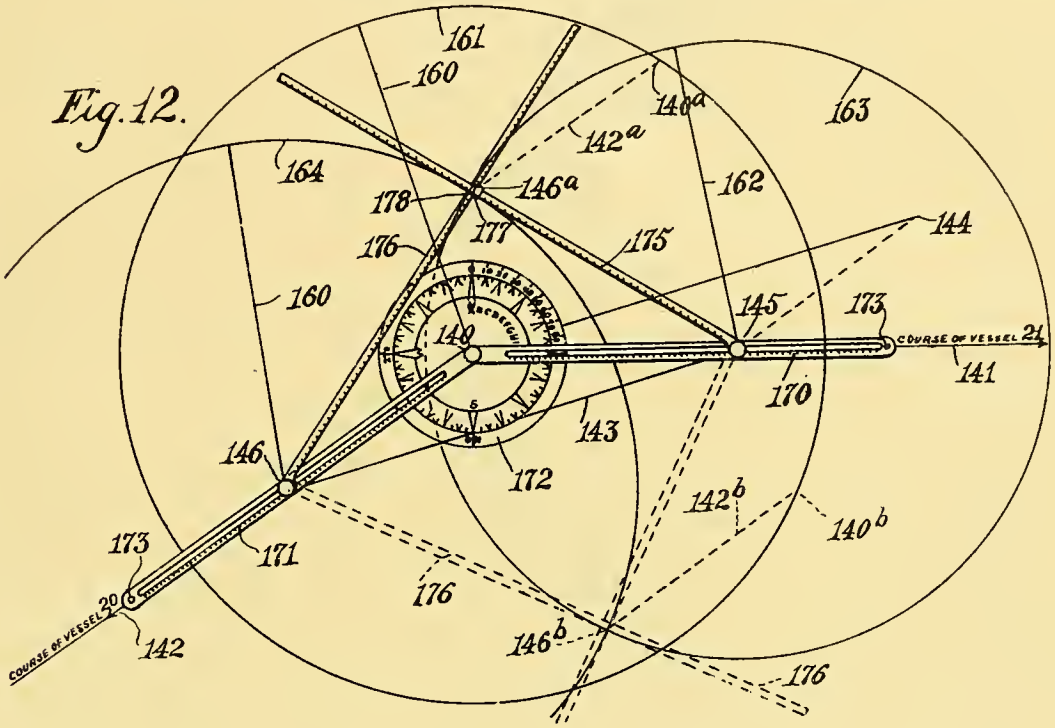
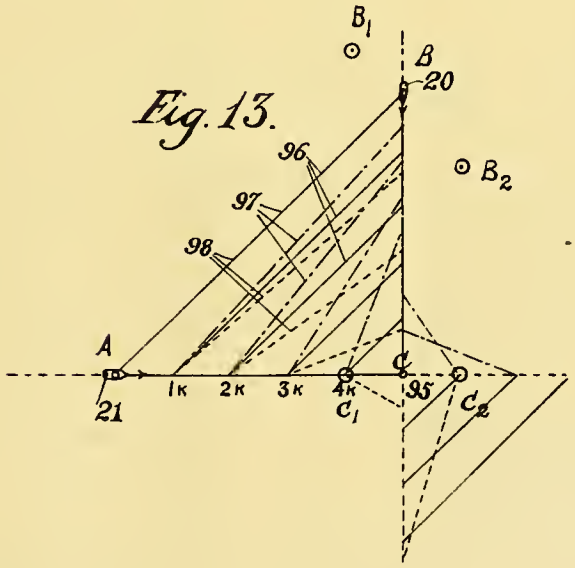
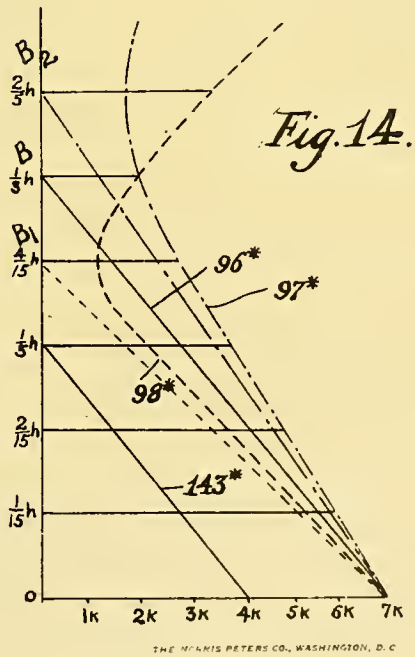
To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.



To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.

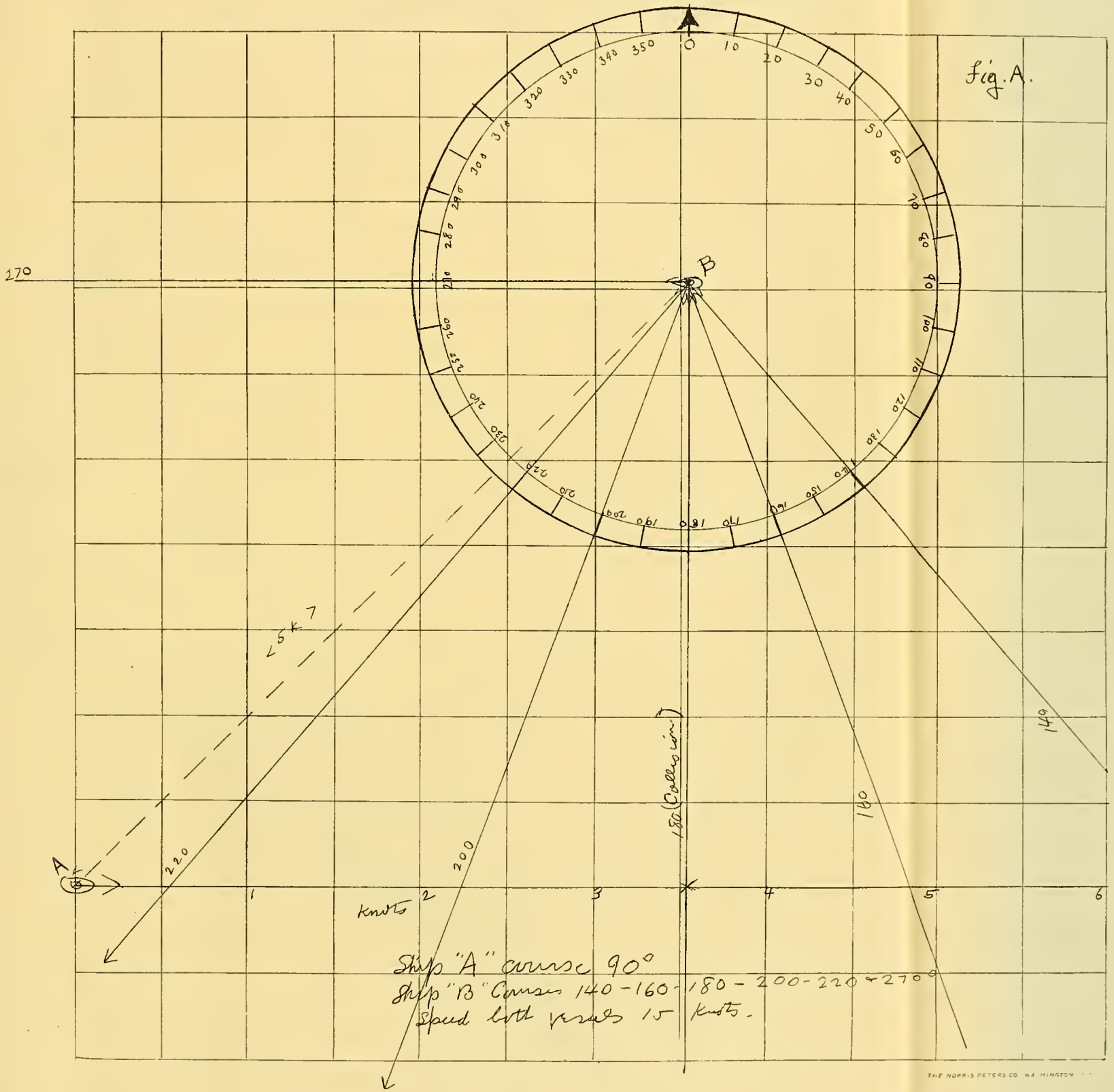






THE HARRIS PETERS CO., WASHINGTON, D. C

To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.



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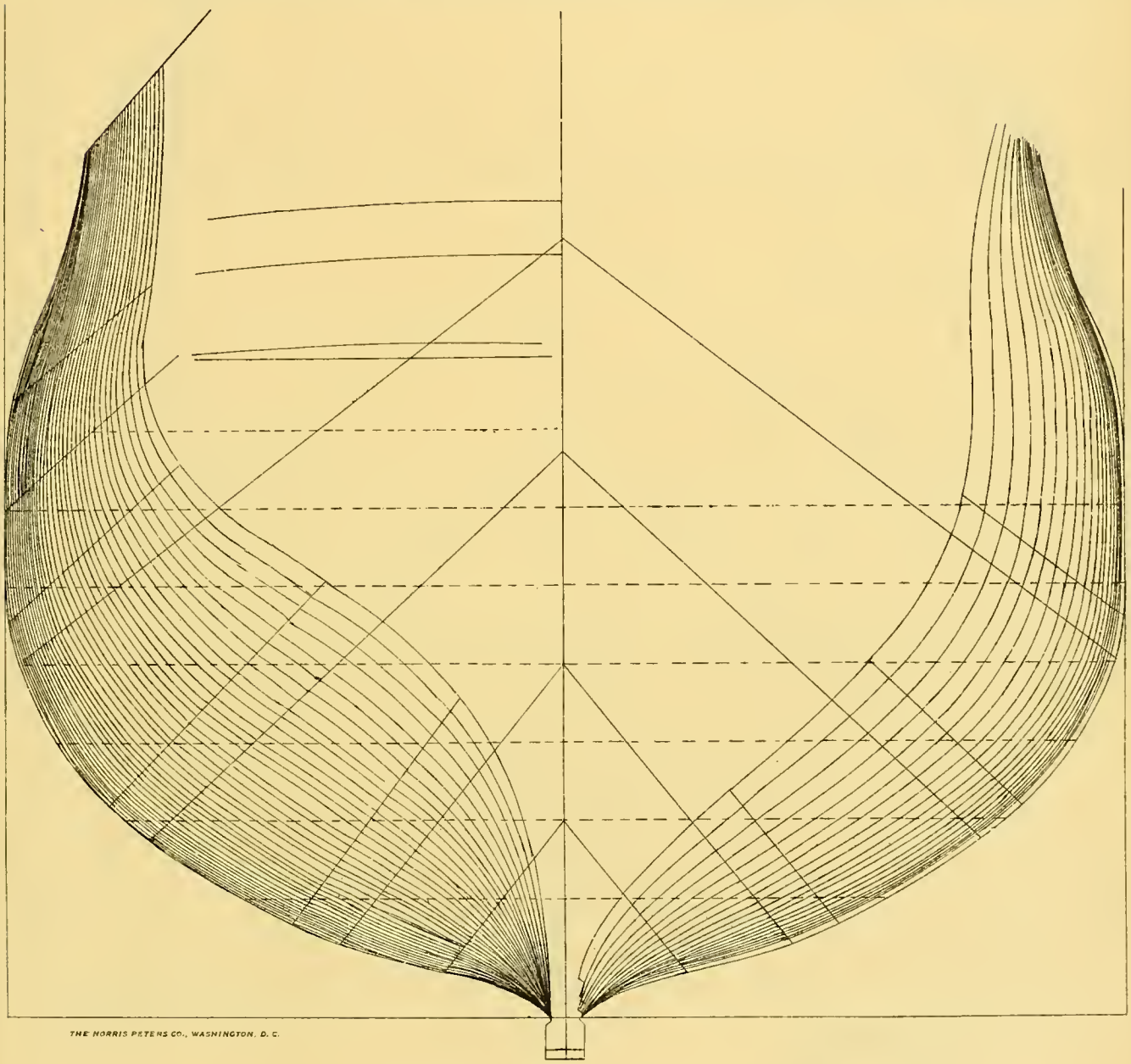
To illustrate paper on "Submarine Signaling and a Proposed Method of Safe Navigation in Fog," by Commander F. L. Sawyer, U. S. N., Member.

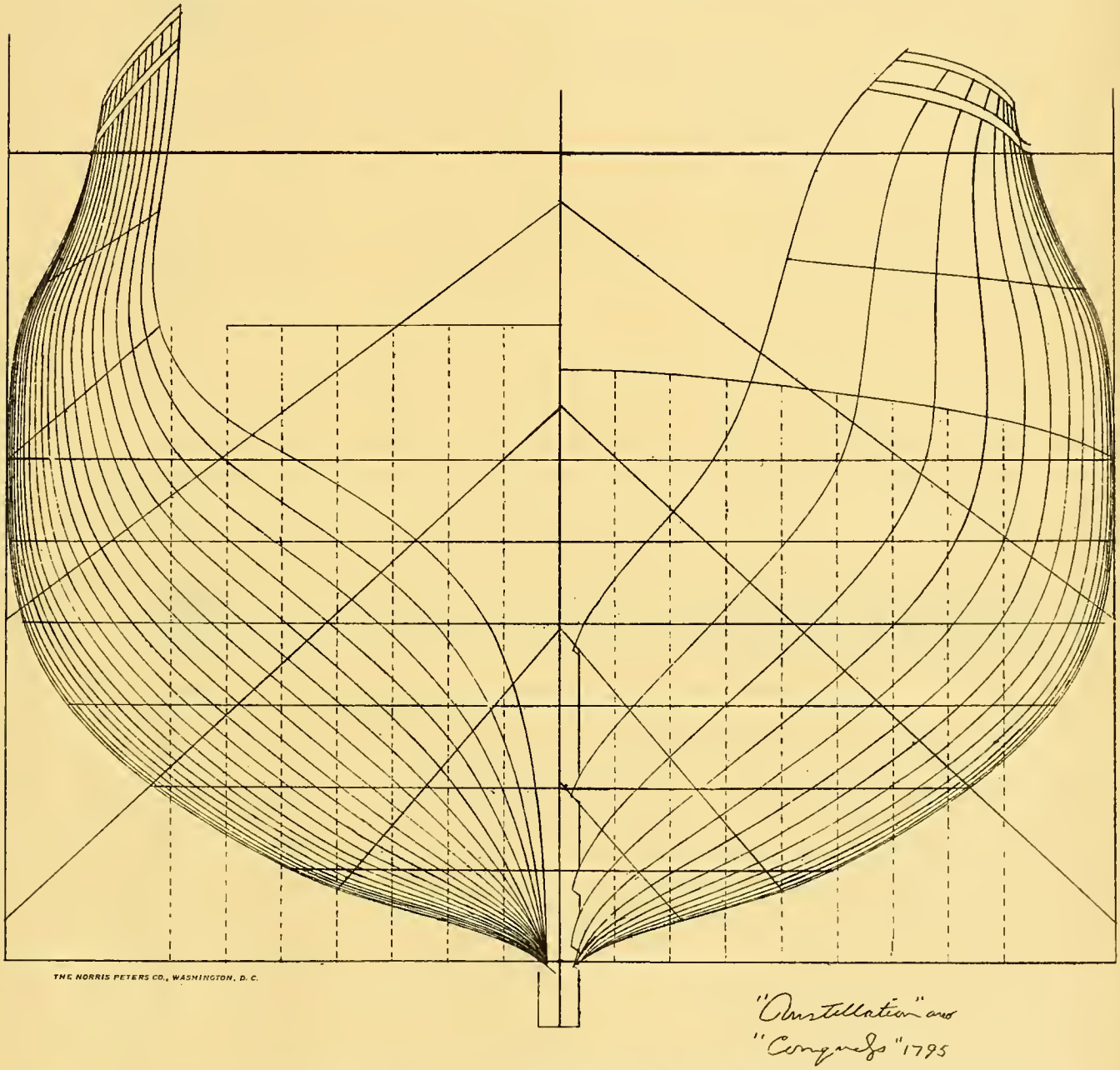
THE NORRIS PETERS CO. WASHINGTON, D. C.

To illustrate paper on "Our First Frigates. Some Unpublished Facts About Their Construction," by Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy.



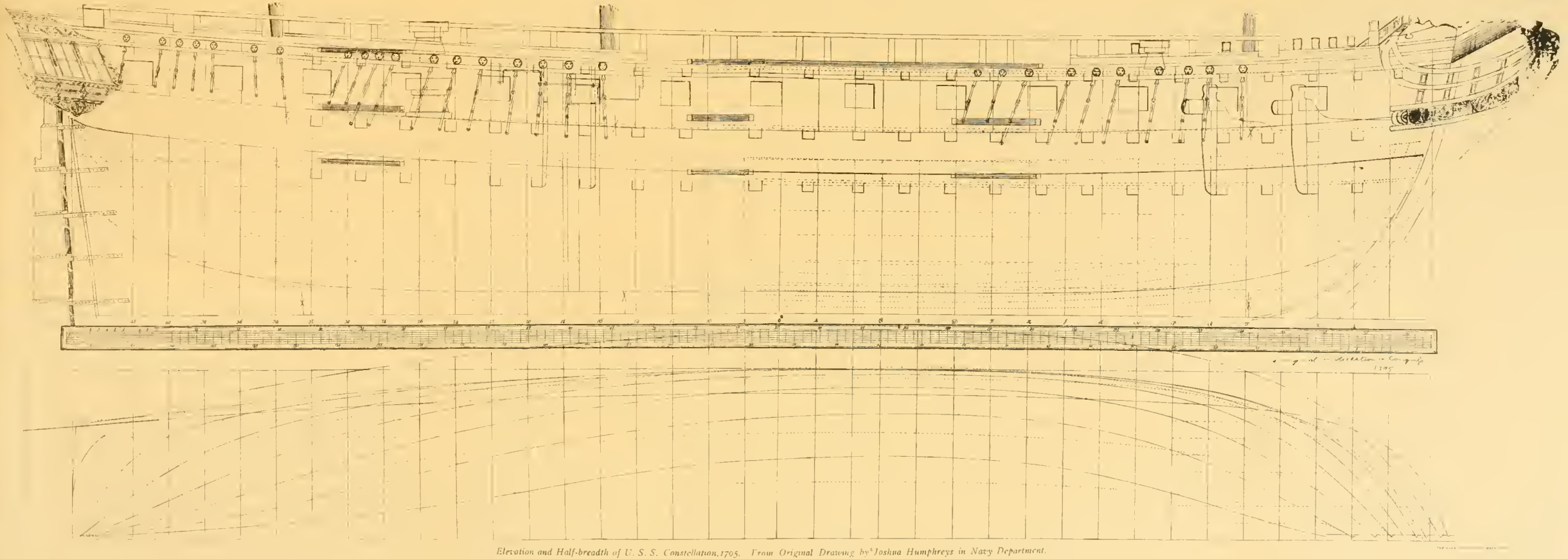
Body-plan of the U. S. S. Constitution and United States, 1794.
From Original Drawing by Joshua Humphreys, in Navy Department.

To illustrate paper on "Our First Frigates. Some Unpublished Facts About Their Construction," by Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy.



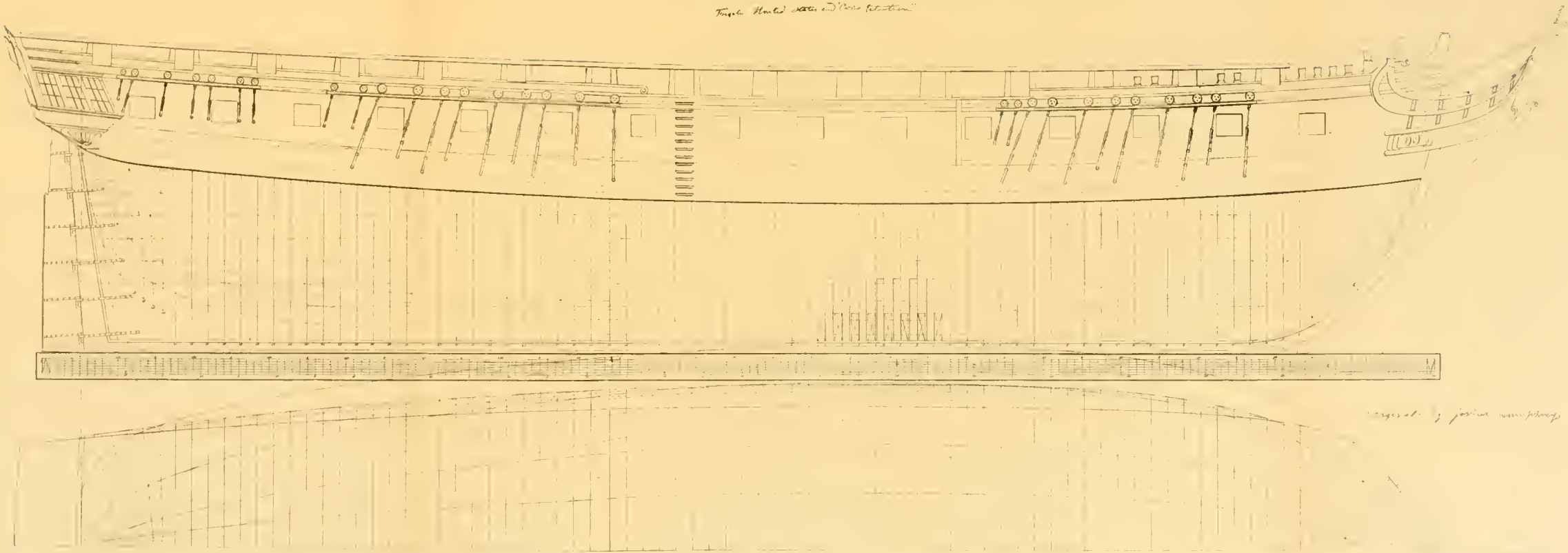
Body-plan U. S. S. Constellation and Congress, 1795.
From Original Drawing by Joshua Humphreys, in Navy Department.

To illustrate paper on "Our First Frigates. Some Unpublished Facts About Their Construction." by Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy.



Elevation and Half-breadth of U. S. S. Constellation, 1795. From Original Drawing by Joshua Humphreys in Navy Department.

To illustrate paper on "Our First Frigates. Some Unpublished Facts About Their Construction," by Hon. Franklin D. Roosevelt, Assistant Secretary of the Navy.



Elevation and Half-breadth of U. S. S. Constitution and United States, 1794. From Original Drawing by Joshua Humphreys, in Navy Department.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

Fig. 1.—Two Photographs of Collier Delivering Coal to a Towing Battleship by the Marine Cableway in 1898, Clearly Indicating the Pitching in a Heavy Seaway.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

Fig. 2.—The Japanese Battleship Hizen (Formerly the Russian Battleship Retvizan) is Here Seen Taking Coal from Cruiser Asia in the Baltic Sea. The Upper Line is the Main Cable. It Was Held Taut by a Sea Anchor Astern the Asia. The Sea Anchor is Now Regarded as Obsolete.

Fig. 3.—Preliminary Test—U. S. S. Iowa Coaling from U. S. Collier Vestal.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

Fig. 4.—U. S. S. Virginia Coaling from U. S. Collier Vestal. Note the Tow Lines Dragging in the Sea. Both Ships Operating Their Propelling Engines Regulated to Give the Utmost Practicable Deflection or Sag in the Hawser.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

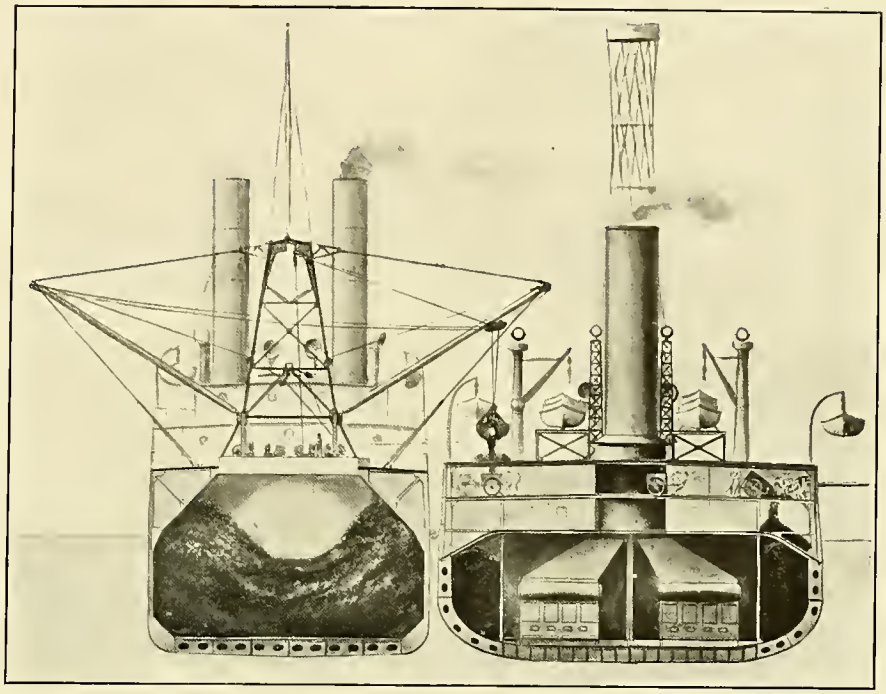


Fig. 5.—Coaling Alongside in Smooth Water. Marine Transfer on U. S. Colliers Jason, Orion and Neptune. Capacity 100 Tons Per Hour Per Hatch with One Operator.

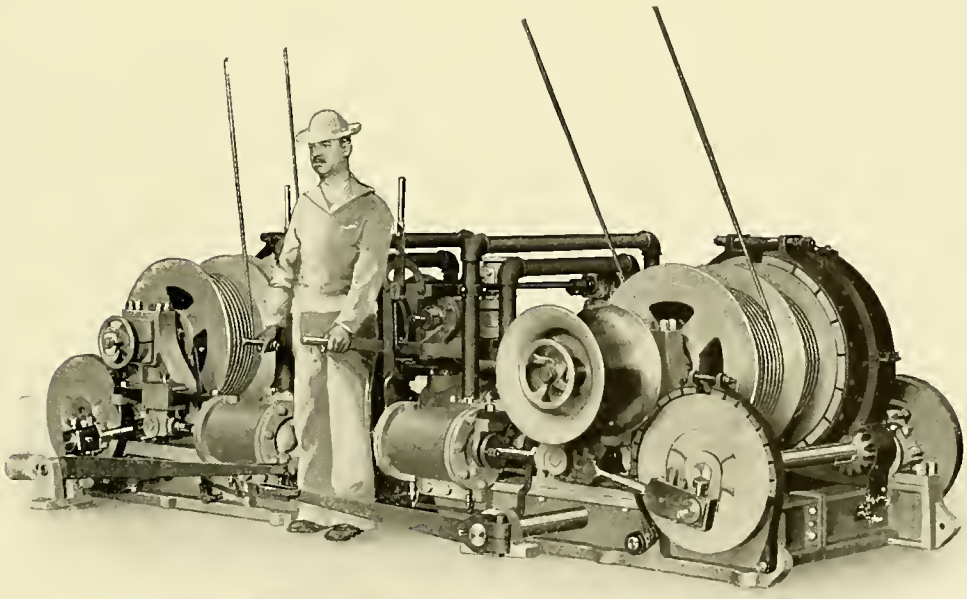


Fig. 6.—Marine Transfer Winches for One-man Control on U. S. Colliers Jason, Orion and Neptune.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

FIG. 7.—U. S. S. SOUTH CAROLINA COALING FROM U. S. COLLIER CYCLOPS. THE FIRST LOAD ABOUT TO LAND.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

Fig. 8.—Haul-down Block and Load Carriage Taking Load from Deck of Collier. It Requires about 5 Seconds to Hook on 3,700-Pound Loads and Raise Them Clear of the Deck.

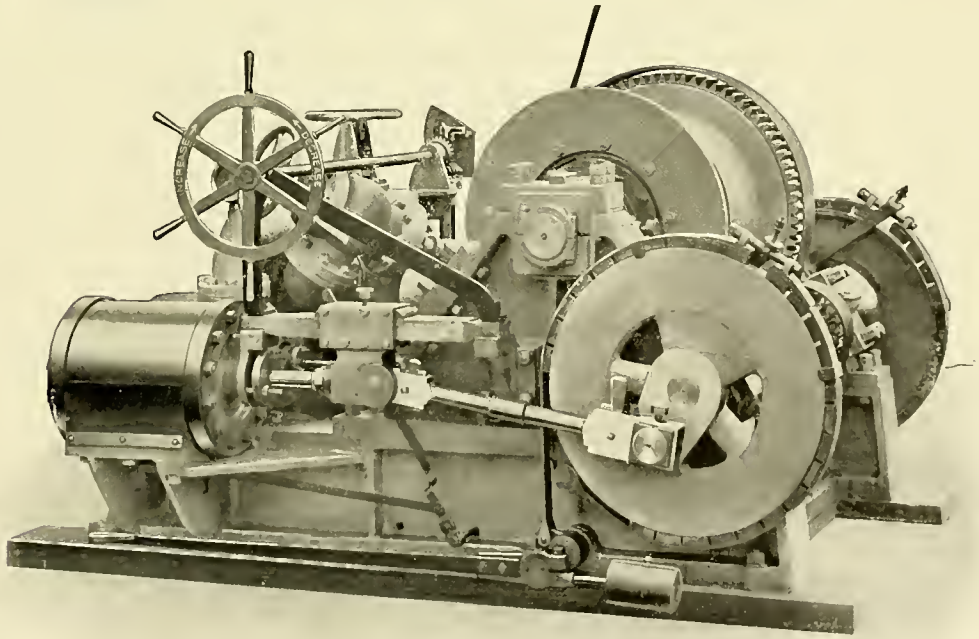


Fig. 9.—Automatic Tension Engine (13″ x 13″) on Collier to Maintain a Constant Tension in the Main Trackway Cable of 18,000 Pounds. This Machine Displaced the Sea Anchor of Earlier Marine Cableways.

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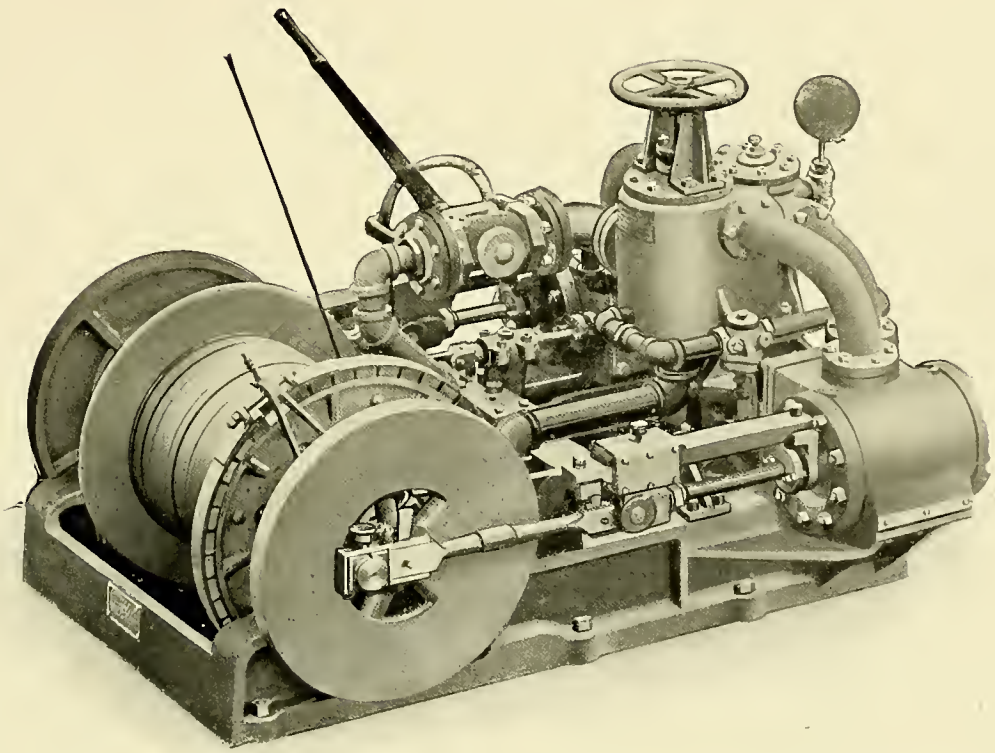

FIG. 10.—10″ x 10″ AUTOMATIC TENSION ENGINE. TWO OF THESE OPERATE THE CARRIAGE FROM COLLIER TO WARSHIP AND MAINTAIN A UNIFORM TENSION IN THE CONVEYING ROPES WHENEVER LOAD CARRIAGE STANDS STILL.

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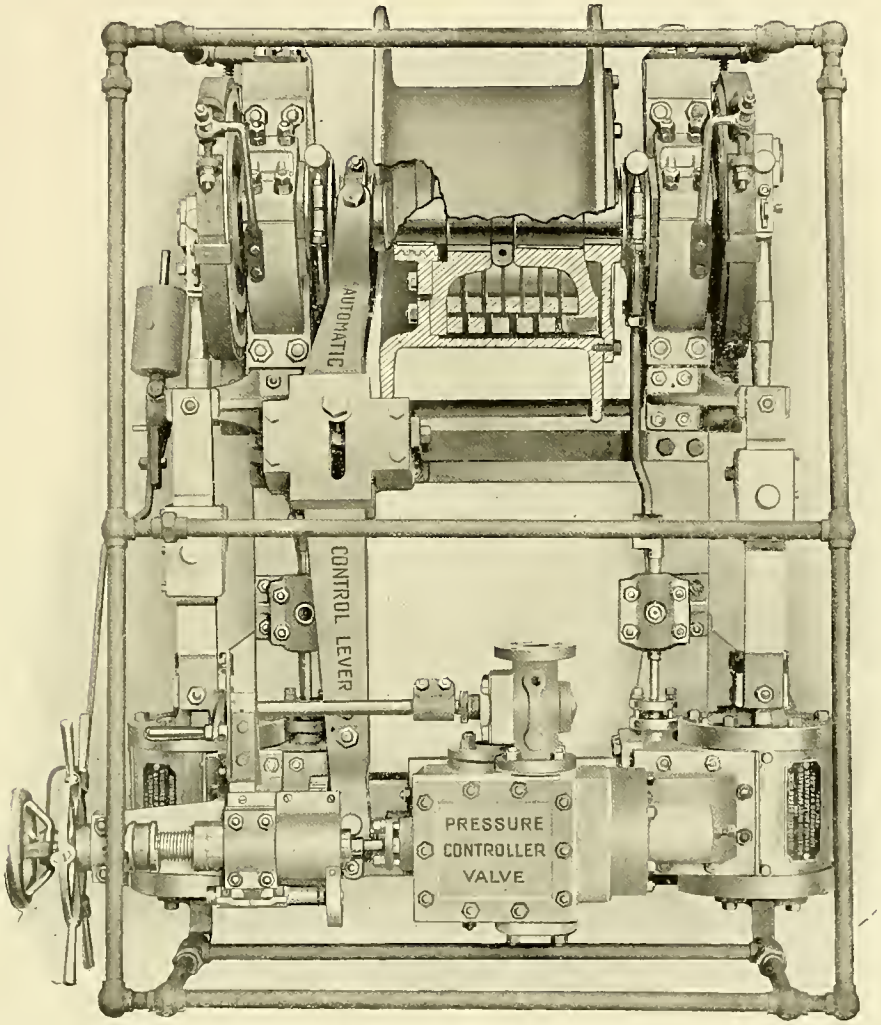

FIG. 11.—CROSS-SECTION OF SPRING DRUM OF SMALL AUTOMATIC TENSION ENGINE SHOWING LEVER CONNECTIONS BETWEEN DRUM AND PRESSURE CONTROLLER VALVE. THIS MACHINE IS USED IN CONNECTION WITH BREECHES BUOY APPARATUS FOR LIFE SAVING AT SEA.

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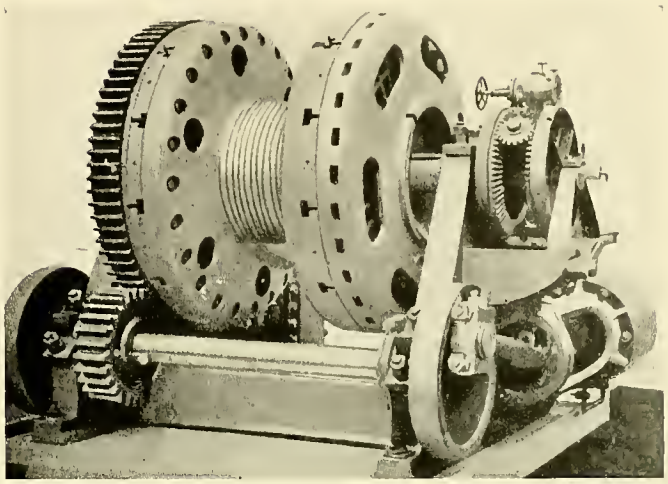

Fig. 12.—Main Cable Tension Engine With Slipping Friction Drum Used on Collier Muriel in British Experiments, 1902. Forerunner of the Automatic Tension Engine (Fig. 9).

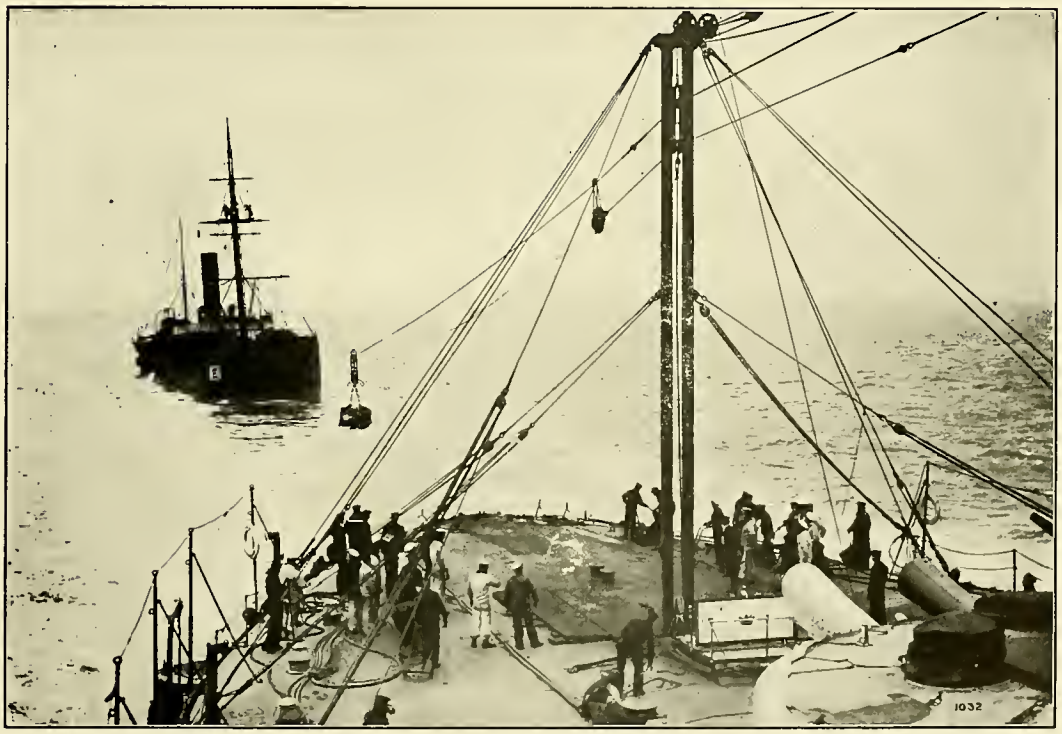

Fig. 13.—Coaling by Marine Cableway. British Experiments, 1902. This Apparatus Was Successfully Tested in Half a Gale of Wind.

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FIG. 14.—ITALIAN COLLIER STEROPE DELIVERING COAL TO THE ITALIAN CRUISER LIGURIA IN A SEA IN WHICH THE SCREW OF THE CRUISER COULD FREQUENTLY BE SEEN ON THE COLLIER.

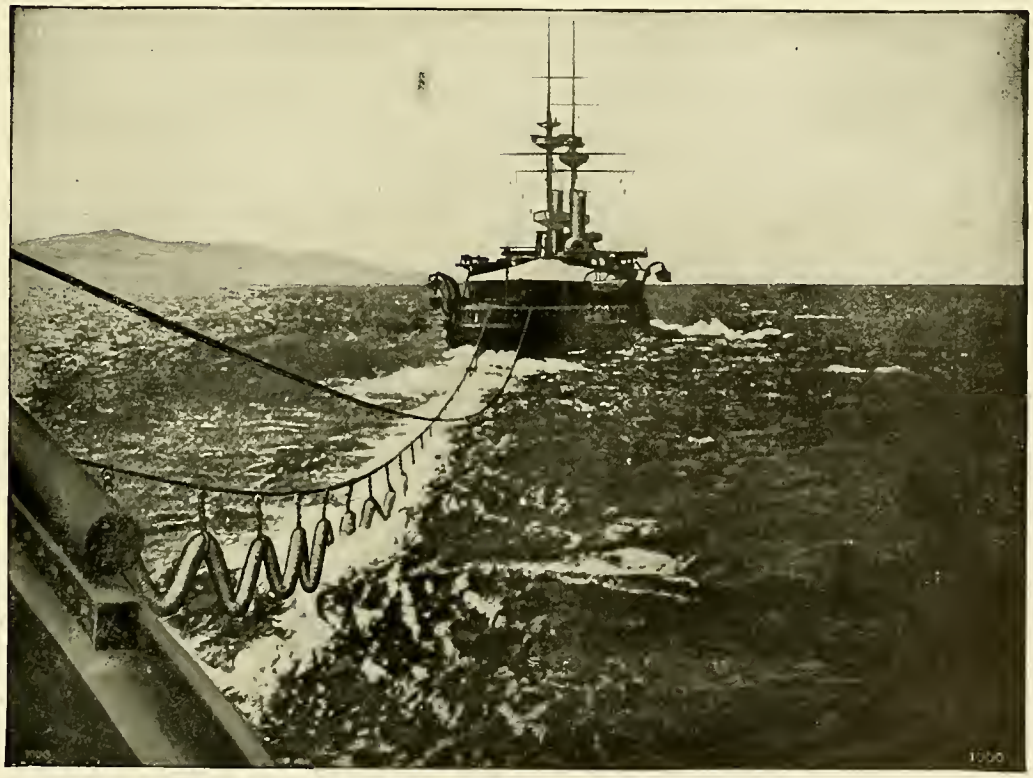

FIG. 15.—OIL BUNKERING AT SEA AS PRACTISED BY BRITISH NAVY.

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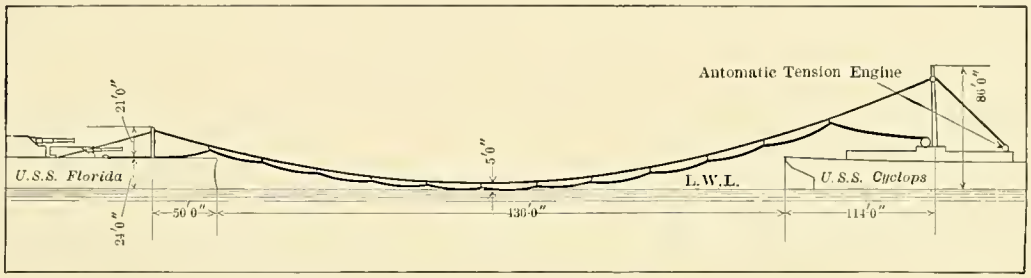

FIG. 16.—OIL BUNKERING AT SEA AS SUGGESTED BY AUTHOR.

PHOTO SUPPLIED BY "PRACTICAL MECHANICS"

FIG. 17.—LANDING GUNS ASHORE. THIS IS ENTIRELY PRACTICAL EVEN IF WARSHIP WAS IN A SEAWAY, IF THE SUPPORTING CABLE IS HELD UNDER CONSTANT TENSION WITH AN AUTOMATIC TENSION ENGINE.

To illustrate paper on "Refueling Warships at Sea," by Spencer Miller, Esq., Member.

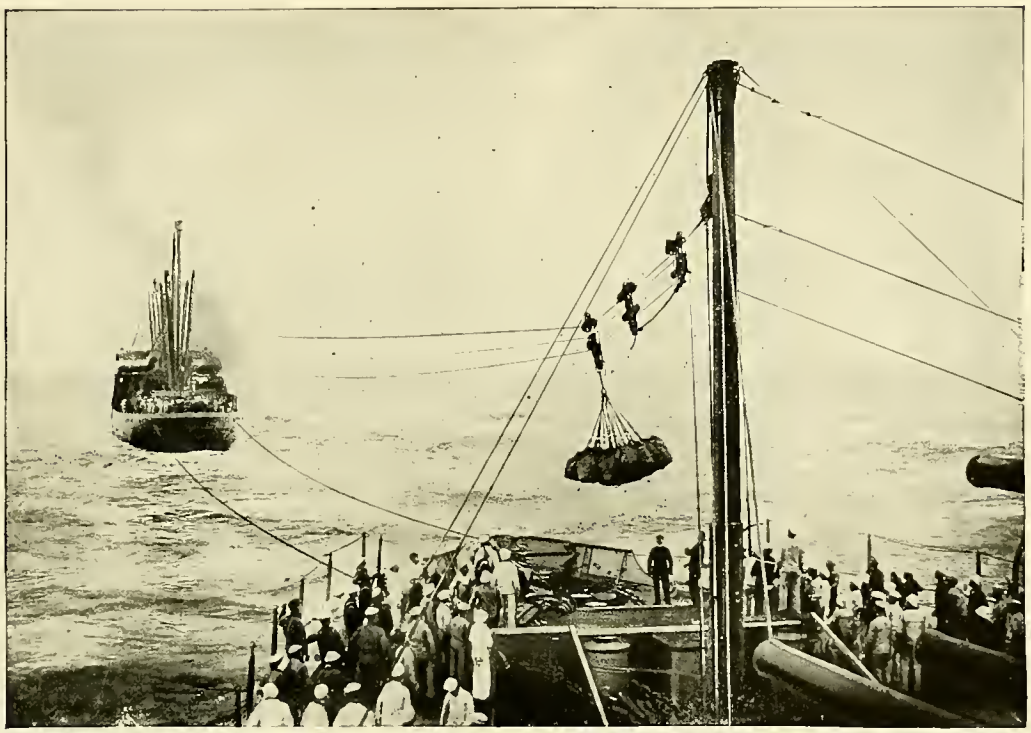

Fig. 18.—U. S. Collier Vestal Coaling U. S. S. Virginia, Showing Portable Pole Mast on Warship. This Pole Mast is a Part of the Collier's Equipment.

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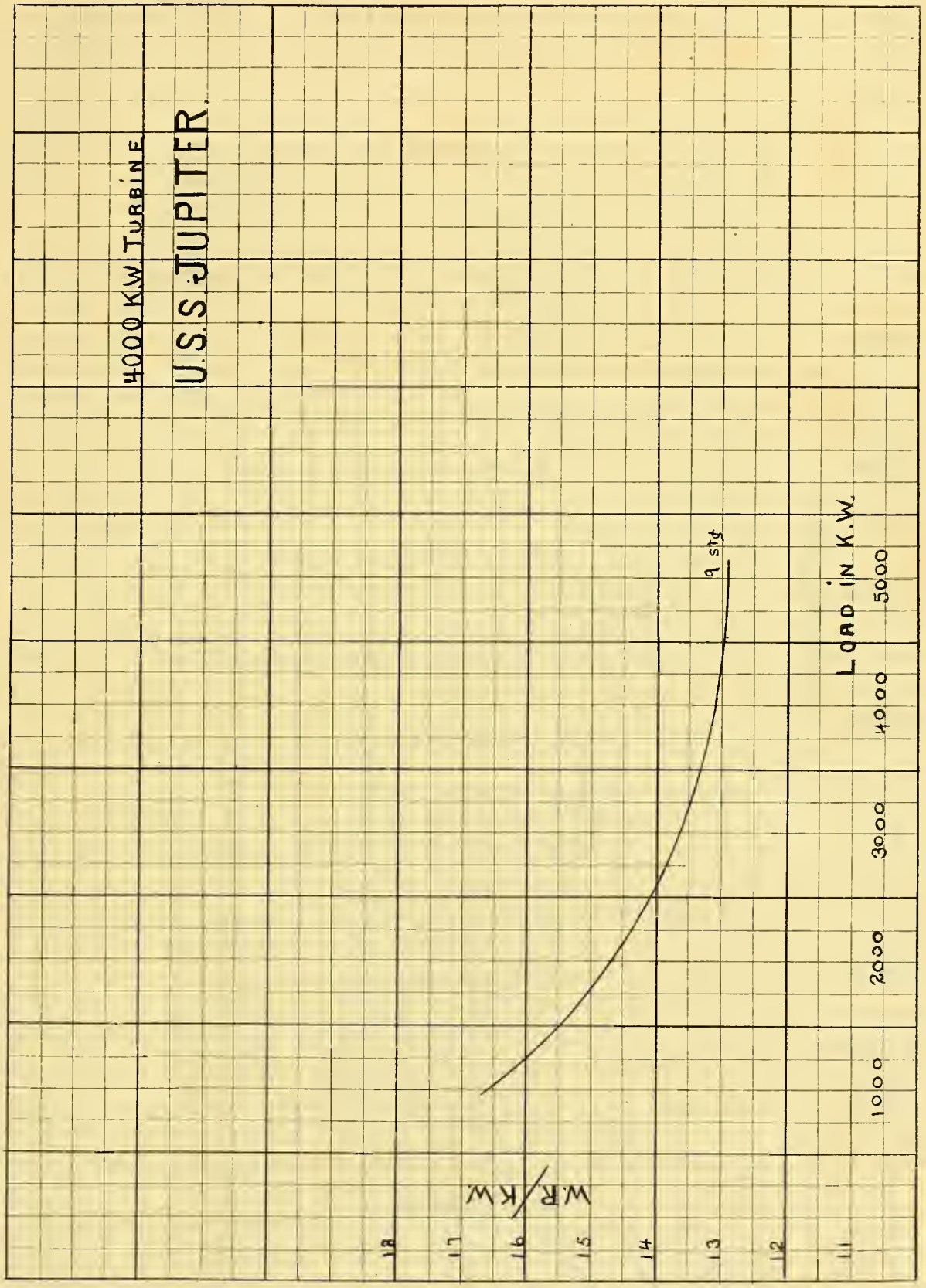

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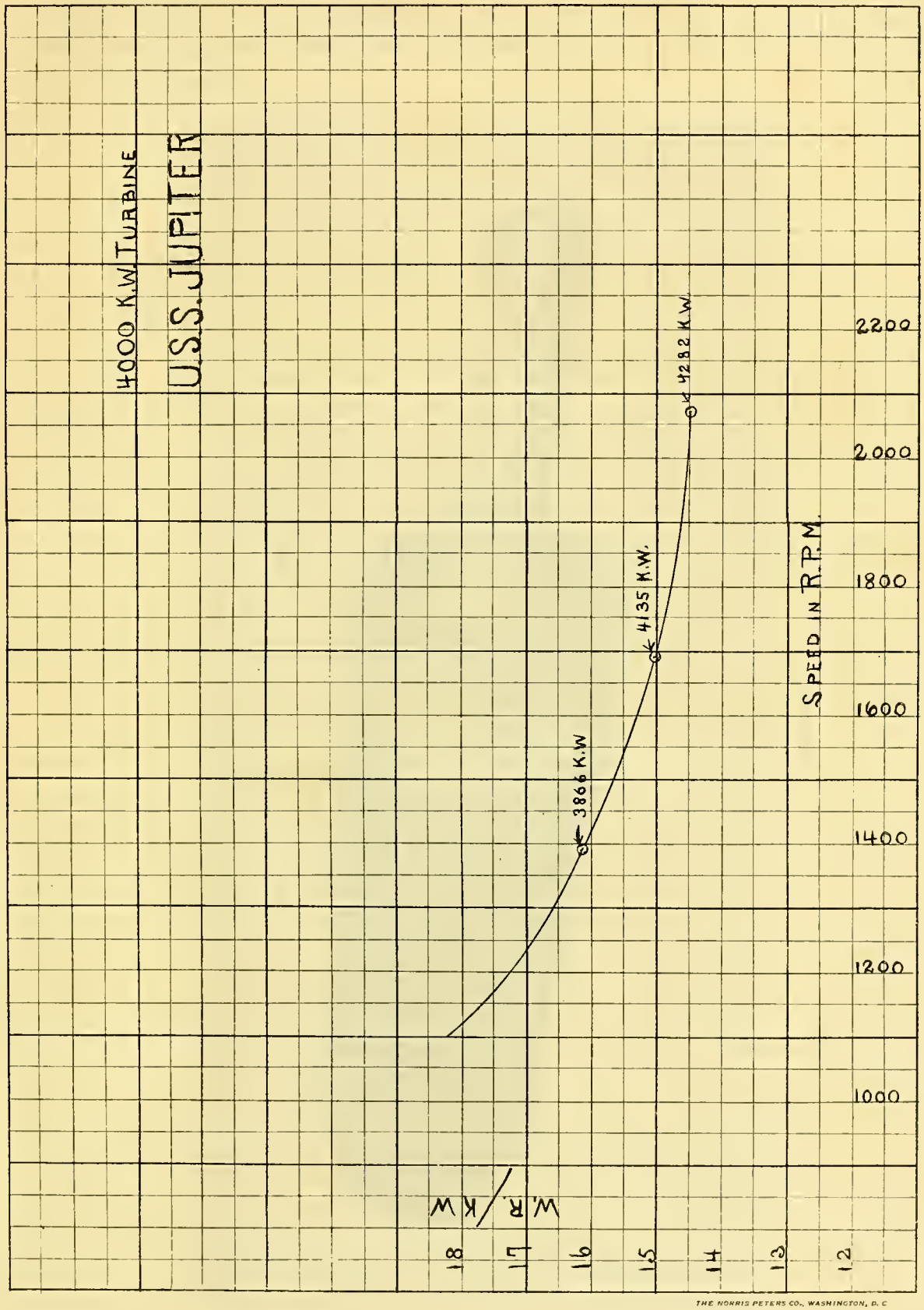

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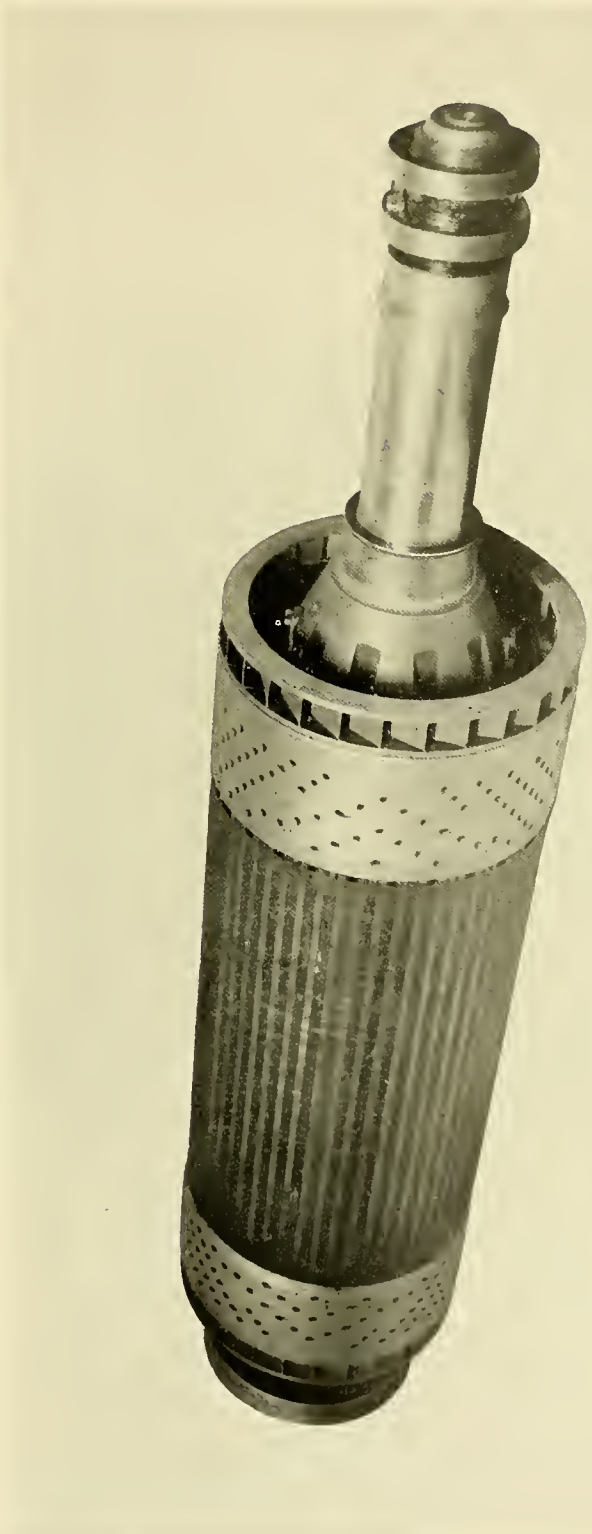

REVOLVING FIELD.

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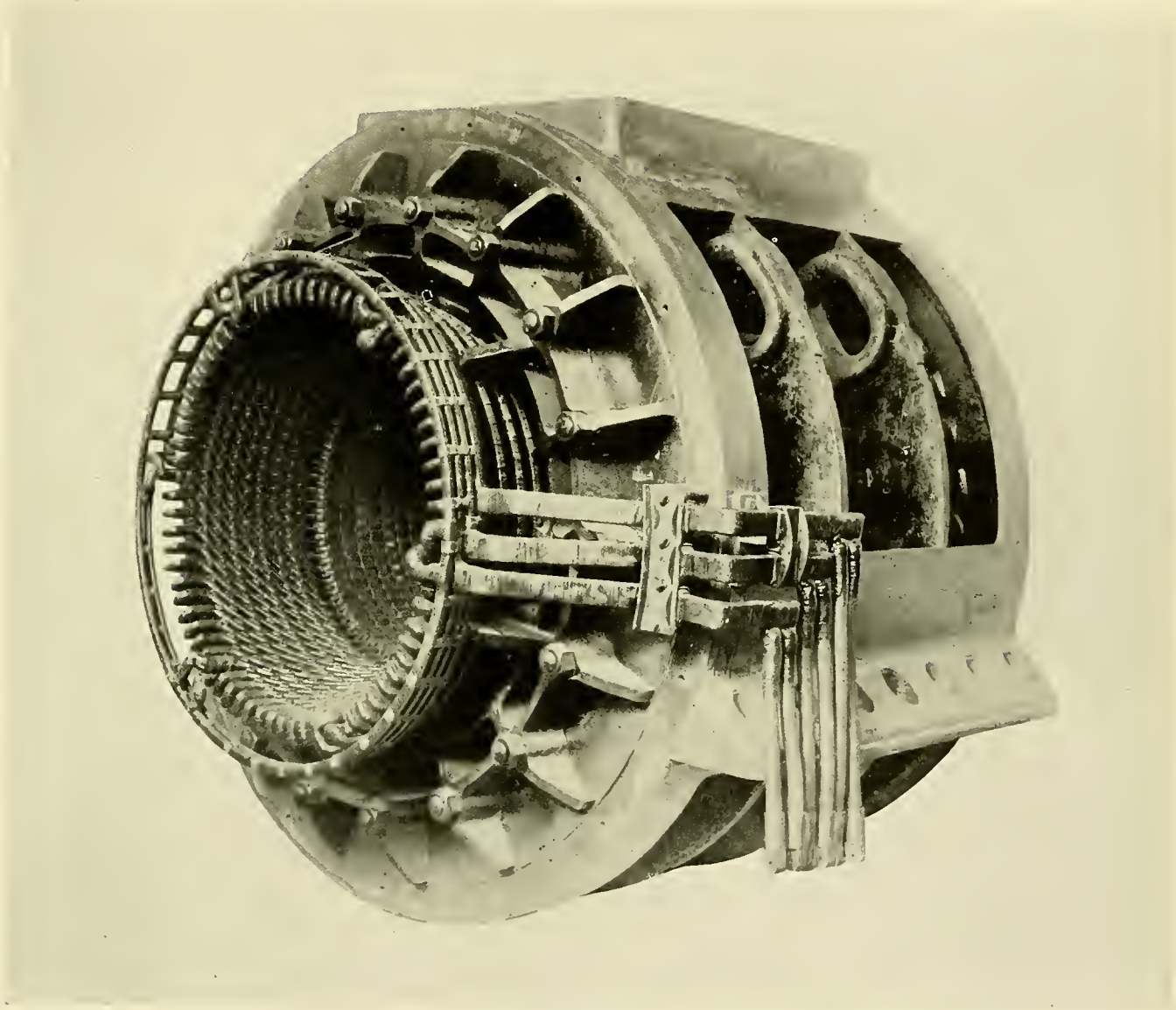

ARMATURE.

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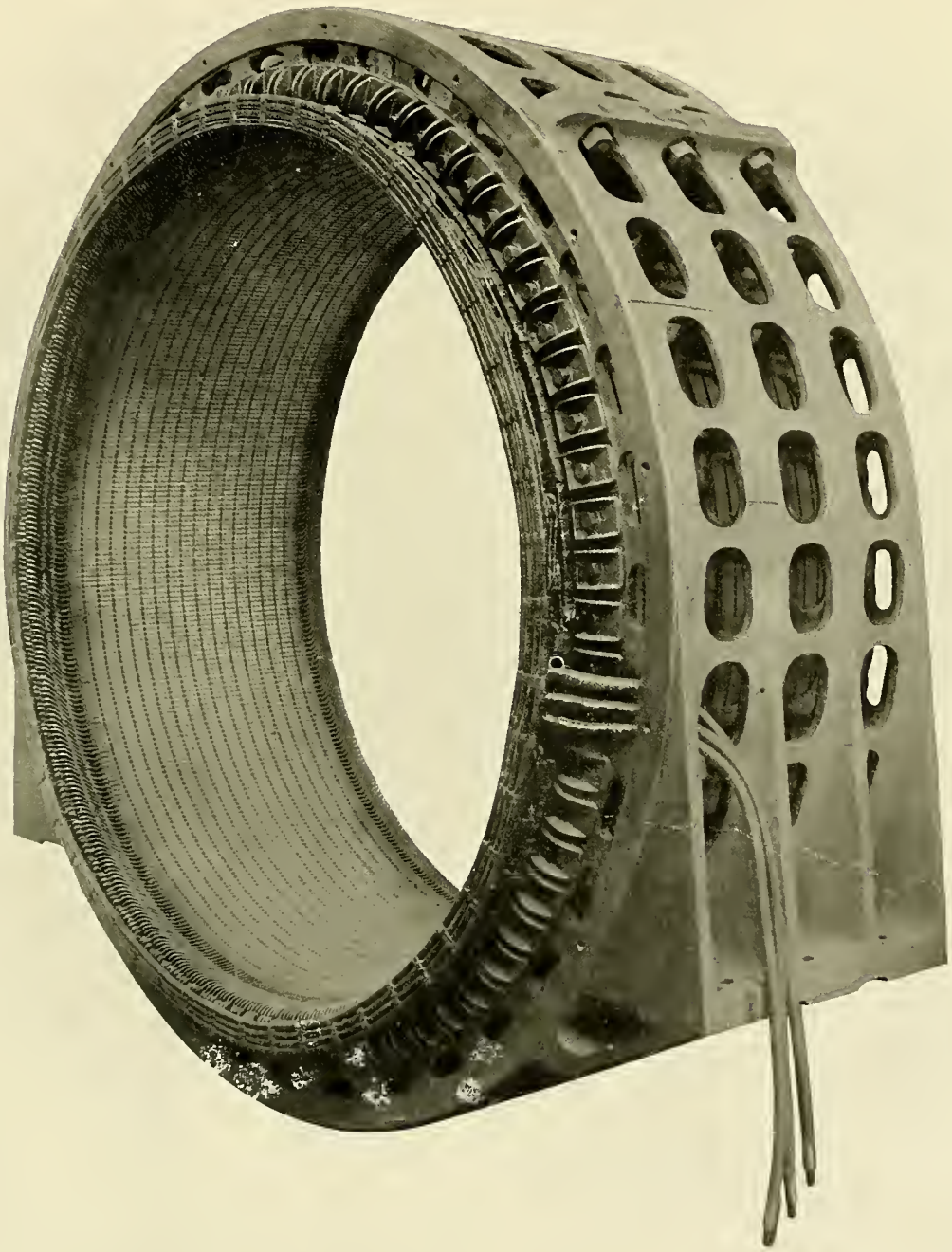

STATOR.

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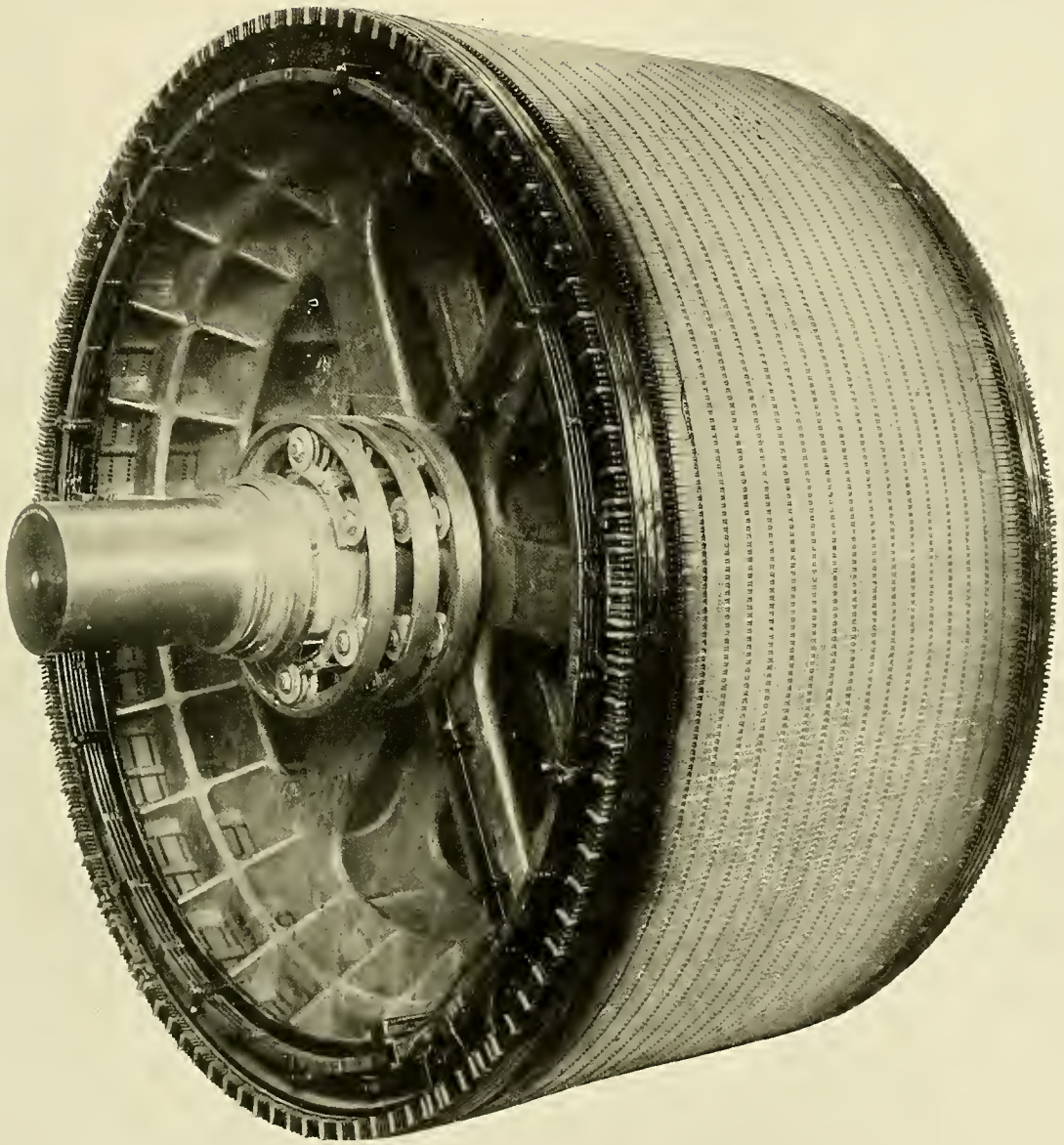

ROTOR.

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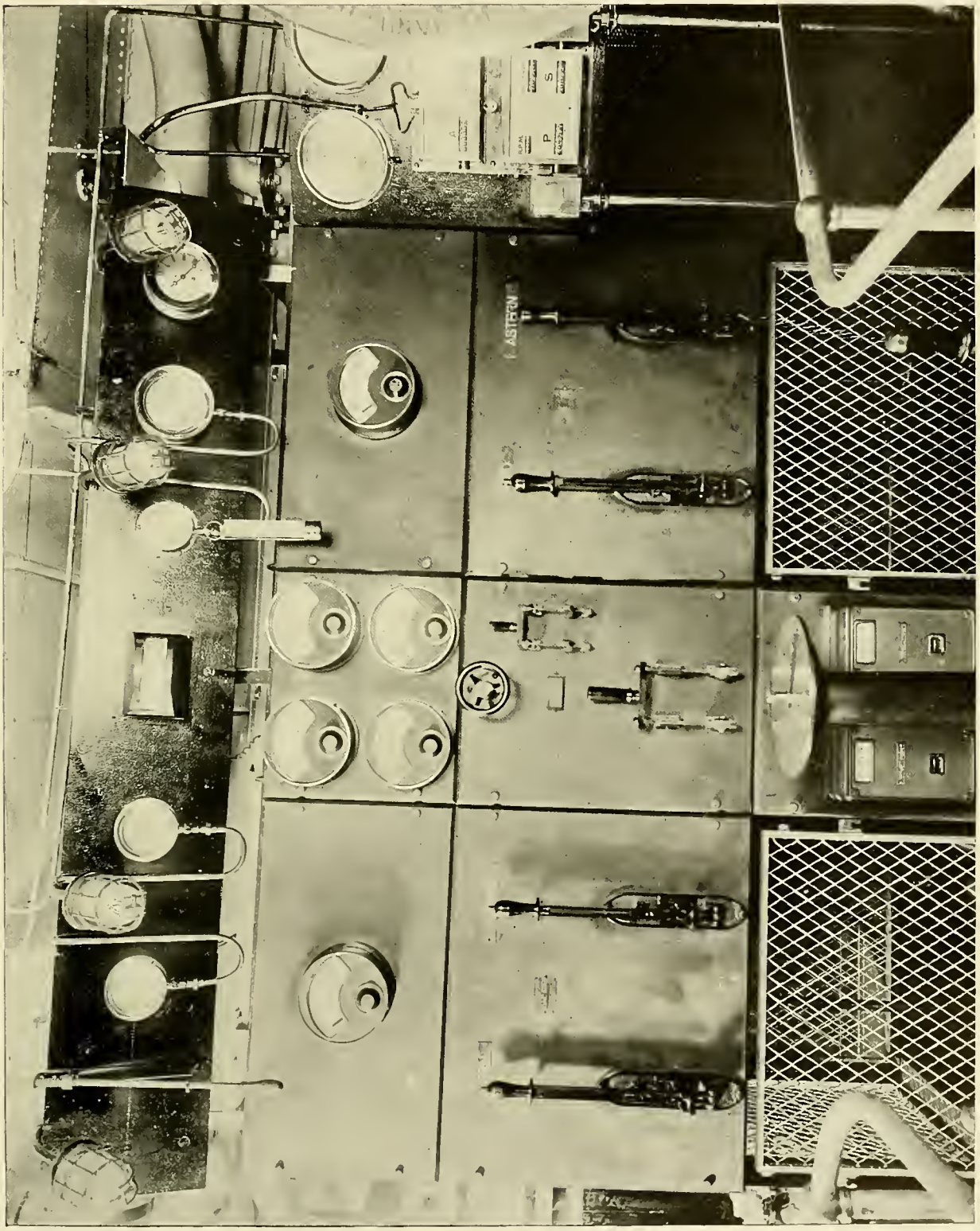

Main Switchboard.

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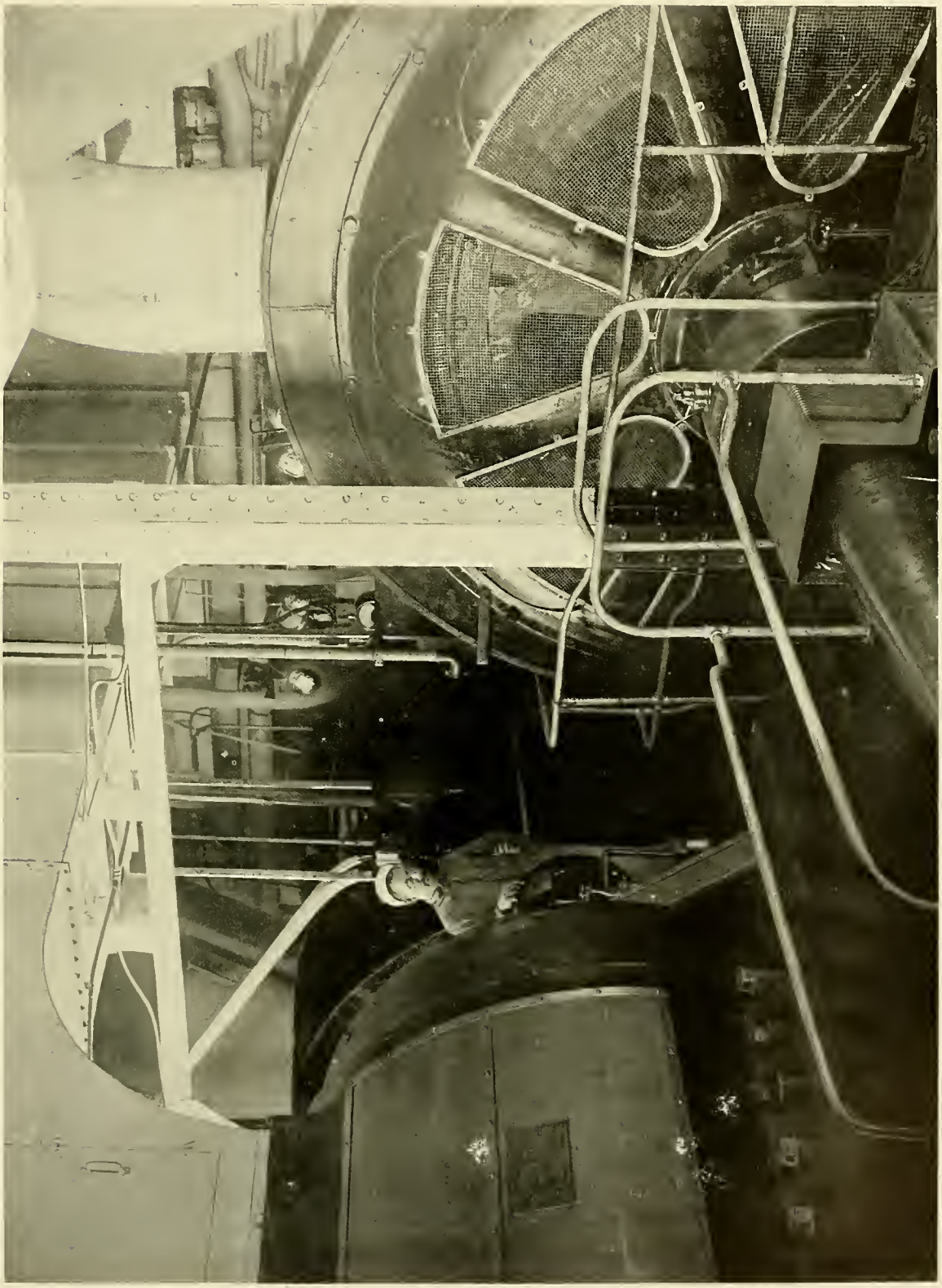
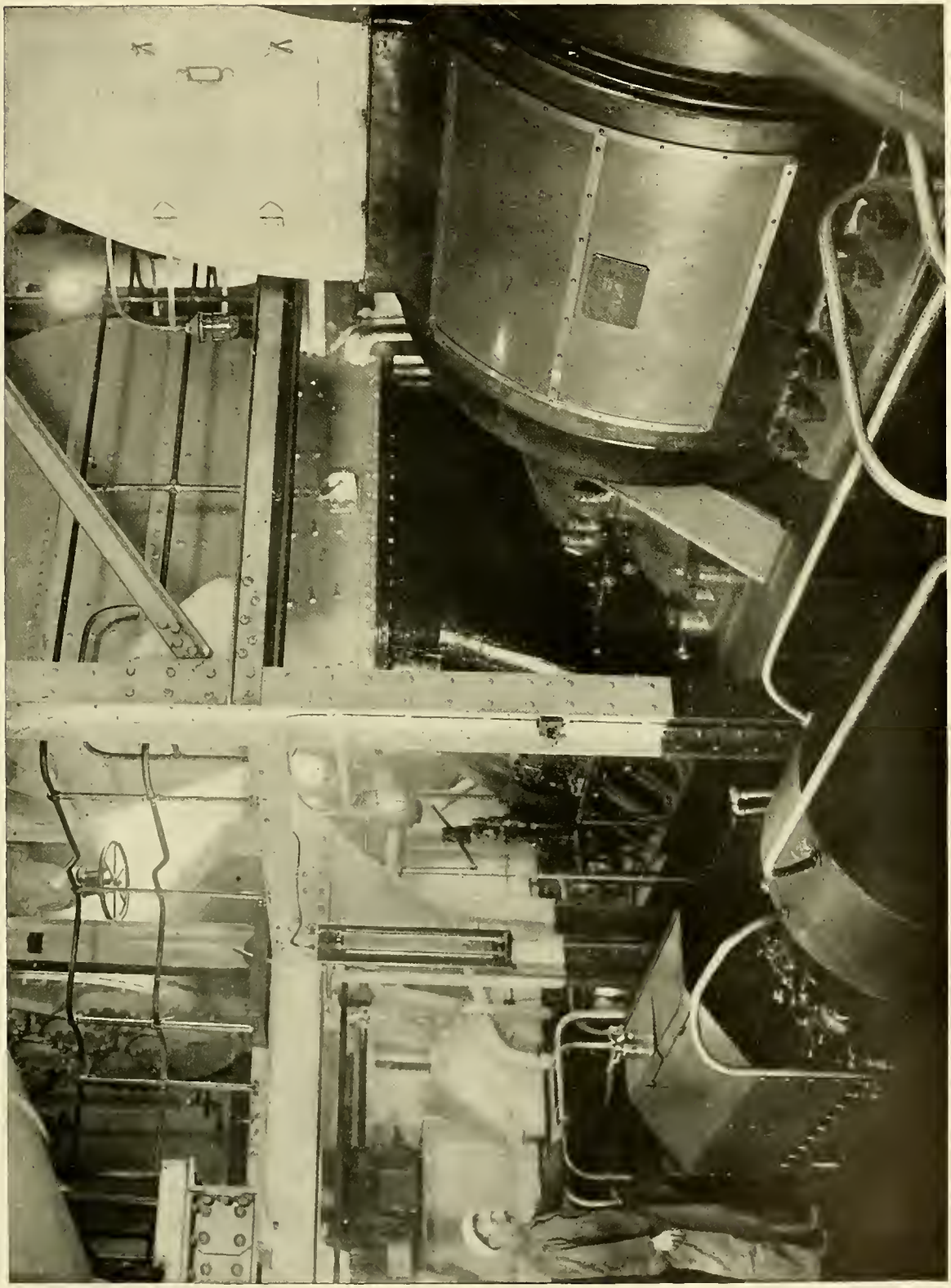


Engine Room. Starboard Side.

To illustrate paper on "The Applicability of Electric Propulsion to Battleships, together with the Experience Gained with it on the Jupiter," by Lieutenant S. M. Robinson, U. S. N., Member.



ENGINE ROOM. PORT SIDE.

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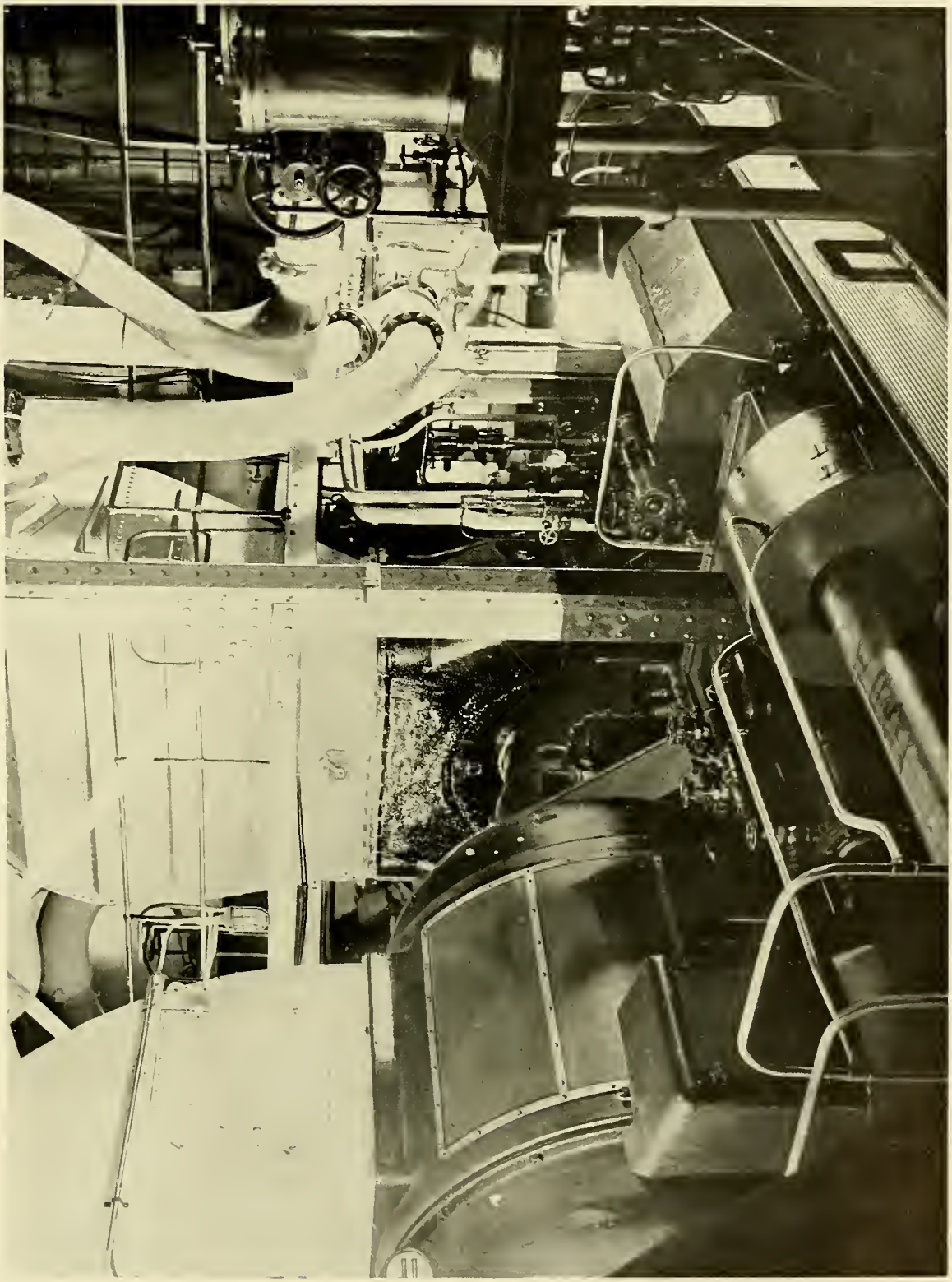

ENGINE ROOM. LOOKING AFT.

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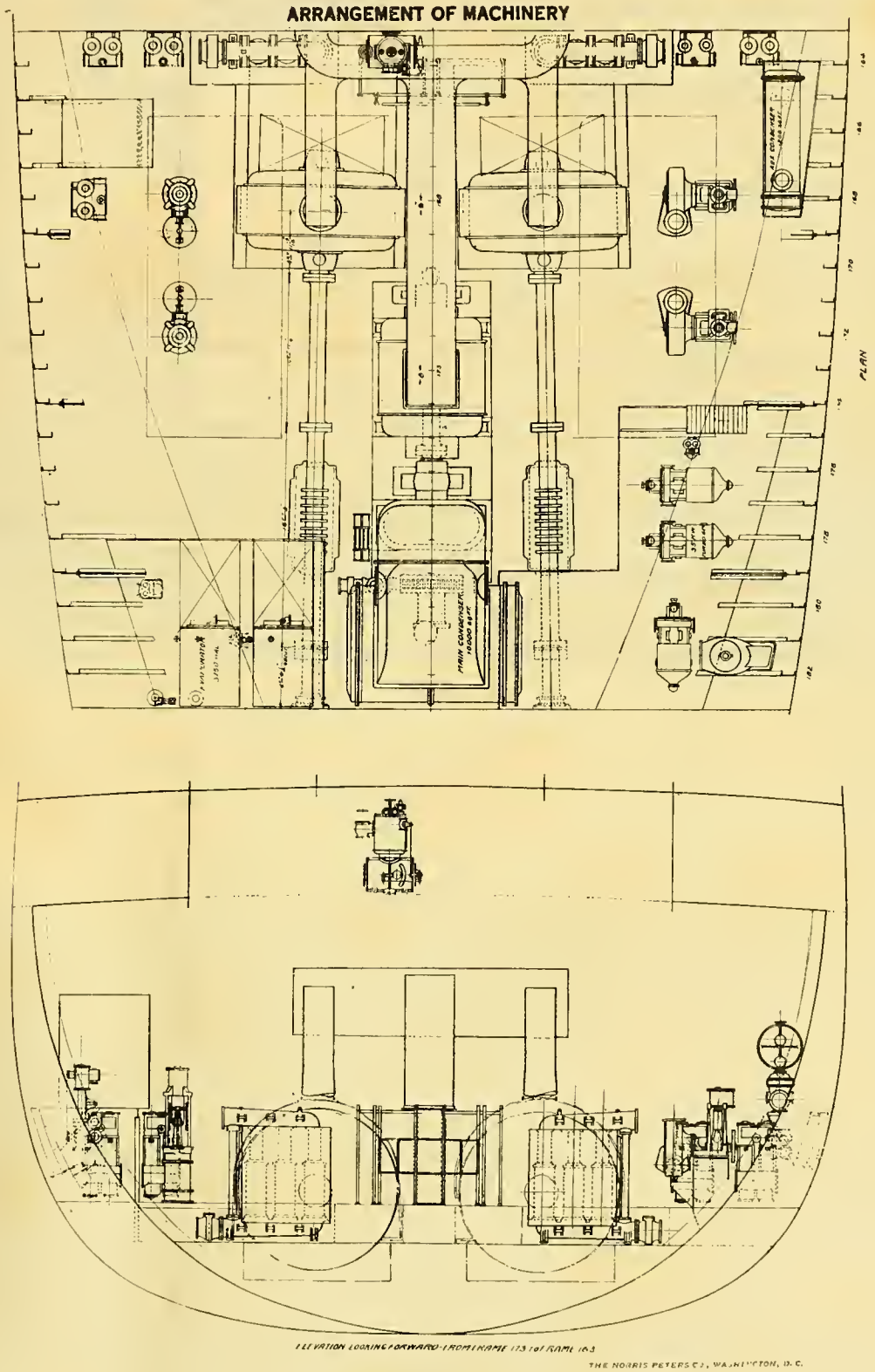
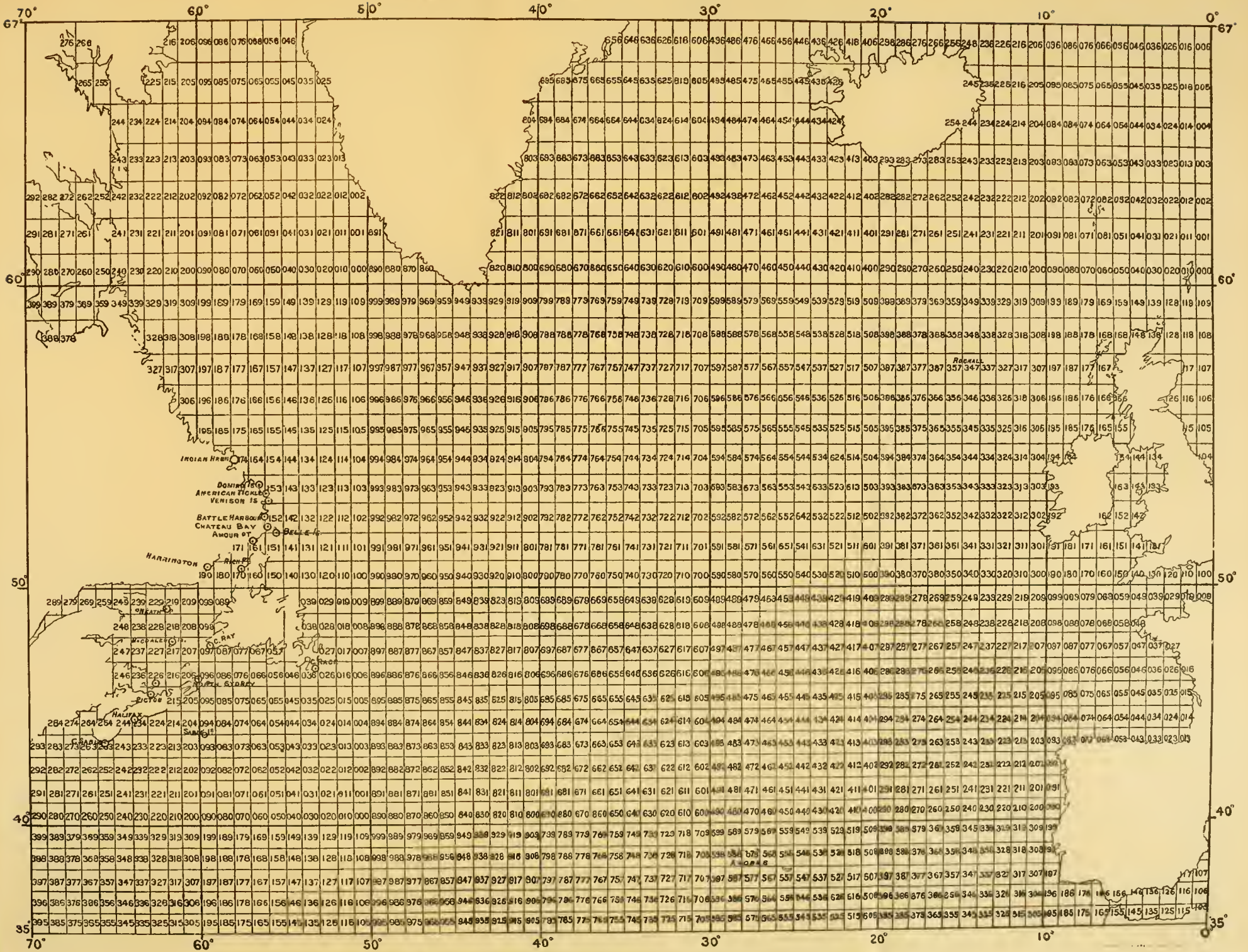


To illustrate the Appendix, "International Convention Relating to Safety of Life at Sea."



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Classification of squares corresponding to one degree to indicate the position of the vessel at the moment of the observation.

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